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ORIGINAL ARTICLES.

I.—Notes on some New Crocodilia from the Eocene of Egypt.

By C. W. Andrews, D.Sc., F.G.S., British Museum (Natural History).

DURING the last few years a considerable number of Crocodilian remains have been collected from the Middle and Upper Eocene beds of the Fayûm, most of these specimens having been obtained by Mr. H. J. L. Beadnell in the course of his excavations in that locality. This material has recently been examined and determined, and it is found that several new species belonging to the genera *Crocodilus* and *Tomistoma* are represented by more or less complete remains. In the present note it is proposed to give a preliminary account of these new forms, which will be fully described and figured in the Catalogue of the Tertiary Vertebrata of the Fayûm now in course of preparation.

The species of *Crocodilus* now described belong both to the broad- and narrow-snouted divisions of that genus.

Crocodilus articeps, n.sp.

Of the latter group only one species has been found; this is represented by an extremely well-preserved skull wanting the posterior region. This skull, which is from the Upper Eocene beds, is taken as the type-specimen. A very perfect mandible from the same horizon and locality probably belongs to the same species.

The general form of the head is much the same as in *C. cataphractus*, the length of the snout being about two and a half times its breadth at the orbits. The upper surface in the pre-orbital region is somewhat flattened, while the sides are nearly vertical. There is scarcely any expansion of the premaxillary region; the facial processes of the premaxillæ extend back to the level of the third maxillary tooth, while the palatine processes reach only to the level of the interval between the first and second teeth. The maxillo-premaxillary suture on the palate is directed backwards. The nasals extend just to the nasal opening, though whether they

actually formed part of its posterior border is doubtful. There are five teeth in the premaxillæ; the anterior pair are comparatively small and have behind them the deep pits for the reception of the anterior lower teeth, which penetrated the upper surface of the snout. The third and fourth teeth are enlarged. In the maxilla, the alveolar border of which is sinuous, the fourth and fifth and the ninth and tenth teeth are the largest. There were twenty-one teeth in all on either side of the jaw. The teeth themselves are mostly lost, but one shows that they had sharp anterior and posterior carinæ and were somewhat flattened on the inner side. This species, for which the name *Crocodilus articeps* is proposed, differs from *C. cataphractus* and *C. intermedius* in the greater length of the nasals and the slighter expansion of the premaxillary region. Of the Eocene species described from other localities it most nearly resembles *C. Ardnini*, Sacco, but differs from it in the smaller degree of expansion of the premaxillary region, the comparative narrowness of the inter-orbital bar, and the less rounded orbits. From *C. Spenceri*, Buckland, the differences are similar. A nearly complete mandible from the same beds is referred to this species. The symphysis is somewhat elongated, extending back to the level of the sixth tooth, but the splenial take no part in its formation. There are fifteen teeth, of which the fourth and tenth are greatly enlarged; the eleventh also is large. In form these teeth are like those of the skull just described. There are well-marked notches for the reception of the upper teeth behind the second, sixth, and seventh teeth, while behind the eleventh and twelfth there are shallow pits.

Some measurements of the type-specimen are:—

	cm.
Distance from anterior angle of orbit to tip of snout	37·0
Width of snout at narrowest	4·8
Width of snout at premaxillary expansion	5·5
Width of skull opposite the front of the orbits	14·0

Crocodilus megarhinus, n.sp.

The Upper Eocene beds also contain remains of a broad-snouted crocodile which seems to have attained a very large size. The anterior part of a skull shows that the premaxillary region was greatly expanded, though longer in proportion to its width than in *C. porosus*. The facial processes of the premaxillæ extend back to the level of the fourth maxillary tooth. There are five premaxillary teeth, of which the third and fourth are very large. Behind the fifth is a very deep and narrow notch for an enlarged mandibular tooth. To this species the name *C. megarhinus* may be applied. Other remains are known, including the symphysial part of a mandible; these will be described elsewhere. The dimensions of the type-specimen are:—

	cm.
Width of premaxillary expansion	15·6
Width at notch	12·2
Distance from posterior border of nasal opening to tip of snout ...	11
Distance from posterior end of premaxillæ to tip of snout	24·5

Crocodilus sp.

From the Middle Eocene beds also remains of a broad-snouted crocodile have been collected, but they are so fragmentary that further material is necessary before any attempt to distinguish the species is made.

Of the genus *Tomistoma* one species, *T. africanum*, from the Middle Eocene (Qasr-el-Sagha Beds) of the Fayûm (Geol. Mag. [4], Vol. VIII (1901), p. 443), has already been described. Now two others, one of slightly later, the other of rather earlier date, are to be considered.

Tomistoma gavialoides, n.sp.

In the Upper Eocene beds of the district remains of a gavial-like crocodile are fairly common. One nearly complete skull has been collected by Mr. Beadnell, and it is to this that the following description refers. This species is interesting because in some respects it is intermediate between *Tomistoma* and *Gavialis*, though much nearer the former, its relationship with which is especially marked in the comparative fewness of the teeth (though they are more numerous than in *T. Schlegeli*) and the extension forwards of the nasals to the premaxillæ, between the facial processes of which they run for some distance.

The form of the occipital surface both above and below the foramen magnum is almost exactly as in *Gavialis*, and, as in that genus, the skull roof is wider than in *Tomistoma Schlegeli*, owing mainly to the large size of the supra-temporal fossæ. The orbits differ from those of the recent *Tomistoma* in being more rounded, as in *Gavialis*, but at the same time they have not the prominent borders found in that genus; in the breadth of the inter-orbital bar also the skull is exactly intermediate. The snout narrows less suddenly than in *Gavialis*, but not quite so gradually as in *Tomistoma Schlegeli*; as in this latter the nasals extend forward to the premaxillæ, in *Gavialis* they are short and separated from the premaxillæ by a long interval. The expansion of the premaxillary region is slight, less than in the true Gavials.

There are 22–23 teeth on either side; in *T. Schlegeli* the number is 20–21, in *Gavialis* 27–29. The premaxillæ bear five teeth, as in the Gavial; in the recent *Tomistoma* there are only four, though in some fossil species referred to this genus there are five. The maxillary teeth seem to have been almost equal in size throughout the series, and to have been directed somewhat outwards and forwards, both Gavial-like characters.

This skull resembles in many respects that described by Toula and Kail[1] under the name *Gavialosuchus eggenburgensis*. This species also is in many ways intermediate between *Tomistoma* and *Gavialis*, but has been referred by Lydekker to the former genus. It differs from the present species in the narrower skull roof, the smaller temporal fossæ, and the raised borders to the orbits; but at

[1] "Ueber einen Krokodil-schädel aus den Tertiärablagerungen von Eggenburg": Denksch. Akad. Wiss. Wien, Bd. L (1885), p. 299, pls. i–iii.

the same time, if it were to be regarded as generically distinct from *Tomistoma*, both it and the present species might perhaps be placed in the same genus, *Gavialosuchus*.

The dimensions of the type-specimen are:—

	cm.
Length of occipital condyle to tip of snout	64·0
Width between outer angles of quadrates	27·0
Greatest width of skull roof	18·0
Width of middle of rostrum	6·4

TOMISTOMA KERUNENSE, n.sp.

An imperfectly known species from the Birket-el-Qurun Beds (Middle Eocene), which are separated from the Upper Eocene deposits containing *T. gavialoides* by the thick Qasr-es-Sagha series, in which *Tomistoma africanum* occurs.

The best specimen is a part of a skull, in which most of the region behind the middle of the orbits as well as the premaxillary portion of the rostrum are wanting. It differs from *T. gavialoides* in having a rostrum which narrows more gradually and the upper surface of which is more regularly convex from side to side; the orbits also are less rounded and the inter-orbital bar broader than in that species. The teeth were larger and are separated by longer intervals. To this species the name *Tomistoma kerunense* may be given.

The reptilian remains from these Egyptian beds are of far less interest than the mammals, since they differ little from their modern representatives. In *Tomistoma gavialoides*, however, we may have an intermediate form, showing how the highly specialized fish-eating Gavial may have arisen from a *Tomistoma*-like reptile, a supposition that is strengthened by the fact that no remains of a true Gavial are known from earlier beds. Dr. E. Fraas has lately announced[1] that he has remains of a species of *Tomistoma* from the lower beds of the Middle Eocene of the Mokattam Hills at Cairo. When these specimens are described perhaps some further light may be thrown on the interrelations of the various long-snouted Crocodilia.

II.—Some Changes of Level in the Glacial Period.

By T. F. Jamieson, F.G.S.

In Scandinavia there have been various changes of level during the Glacial period, and some geologists of that country are of opinion that the load of ice which lay upon it affords a probable means of accounting for a depression and submergence of the land such as would lead to the formation of those elevated beds of Arctic shells which are met with in the interior of that region. But there has been a later movement of quite a different nature, whereby the Baltic seems to have been converted for a time into a fresh-water lake, and it is to this that I now want to draw attention, as I think the same cause which has been supposed to produce the depression

[1] "Neue Zeuglodonten aus dem unteren Mitteleocan vom Mokattam bei Cairo": Geol. u. Palaeont. Abhand., neue Folge, Bd. vi, Heft 3; Jena, 1904.

affords a happy means of explaining this curious and later phenomenon also.

The depression of a large tract of land by a weight laid upon it would almost of necessity be accompanied by a corresponding rise in the region lying immediately beyond. We see this on a small scale when we push down a hollow in an elastic substance, or when a depression of the soil is caused by the advance of a heavy mound such as a railway embankment, which leads to a bulging up of the ground immediately in front. The depression of the ice-covered area of Scandinavia would therefore probably produce a similar bulging up of the outer region, and thus close the Cattegat and block out the sea from the entrance to the Baltic, thereby converting it for a time into the state of a fresh-water lake. This would happen probably after the Baltic glacier had shrunk considerably, and it is just then that the fresh-water condition seems to have occurred. At an earlier period, when the Scandinavian ice spread far and wide, the bulging up would take place at a much greater distance, and would embrace a larger area. Here again we have evidence of a like result, for we know that the southern part of the German Ocean and the Straits of Dover were converted into dry land during an earlier part of the Glacial period; and that the mammalian fauna of the continent ranged freely over that ground into England. The lower reaches of the Thames too, and other rivers of East Anglia, were also by the same action probably converted more or less into lakes and pools, which appear to have been haunted by the hippopotamus, whose remains are frequently met with in the valley gravel and alluvial deposits of that quarter. In the South of England and in Germany there are other proofs of straining and earth-movement, due possibly to the same heavy pressure exerted by the Scandinavian ice, and propagated outwards beneath the surface. Movements of depression occasioned by forces of this nature must generally be attended in neighbouring regions by strains, fractures, and movements of elevation, which are to be looked upon as the natural accompaniment and complement of the depression caused by the load of ice. Here, then, it seems to me we may find an efficient cause for the production of many such movements, in regard to which no explanation has hitherto been offered.

One of the most obvious changes in the weight of the surface arises from the action of rain, rivers, and glaciers continually wearing and washing down matter into the sea. This incessant degradation must always be wearing away and lightening the mountain regions, so that the tendency in them should be to a slow and gradual rise, whereas on the sea bottom the opposite effect would take place, and there the tendency would be to sink. Such action would tend to the permanence of continents, which otherwise would be worn down much faster. Land is land, I presume, because it is lighter than the area occupied by the sea, and the great mountain regions are probably the least heavy parts of the earth's crust.

Our ignorance of the state of matters in the interior of the earth is so great that we are not justified in dogmatizing on the subject,

but the facts observed by geologists seem to show that movements of some kind, even in a lateral direction, are possible at no great depth beneath the surface, although the great internal mass of the earth may be as rigid as certain mathematicians would have us believe. Some degree of plasticity or viscosity in a stratum not far down would suffice to allow of all the movements I have assumed to be possible in the foregoing observations. But whether the outer crust reposes on a stratum of this nature or not, it must, I should think, be in a state of equilibrium, or if not it will move. If the downward pressure is not exactly equalized by the upward resistance, movement must ensue to restore the balance. Hence the level of the surface must always be tending to an exact equilibrium, and must respond to any change, however slight, in the load laid upon it. The response no doubt may be quite infinitesimal, but is it not inevitable? We might compare the action to that of a spring of enormous strength, so strong as to be practically rigid to human observation.

If the views of Adhemar and Croll regarding the Glacial period are right, we may believe that in each hemisphere alternations of great cold with warmer intervals took place owing to the precession of the equinoxes. And if a great load of ice on the land really causes a depression, we may infer that each period of glaciation would be accompanied by a depression or submergence proportionate in some measure to the greatness of the load of ice. Now there seems to be evidence that some such train of events actually did occur both in Scandinavia and Scotland, the severity of glaciation finally becoming less, and the amount of submergence also.

The Arctic Shell-beds of Scotland.

I have for a long time been of opinion that in the Clyde district and West of Scotland we have at least two distinct sets of marine beds containing northern shells, viz., (1) an older set which attains to much higher elevations (in one case up to fully 500 feet) and has been more or less destroyed by a subsequent development of glaciers and land-ice; (2) a newer set confined to lower levels and which has never been subjected to the same destructive action. In the latter series the species are much more numerous, the shells much more plentiful and in much better preservation, many being evidently in the spot where the animals lived and died — rows of *Mya truncata*, for example, in the position of life, with pieces of the siphuncular tubes still remaining. It is from this series that Mr. Smith, of Jordanhill, got most of his specimens. These two series of shell-beds, I believe, were separated by a long period of land-ice which heavily covered all the west side of Scotland and spread more lightly over the eastern side. I think, therefore, they ought not to be confounded together as has been generally the case, seeing that a great lapse of time and an important change of conditions intervened between them. In the older set the shells are generally more or less crushed and are often covered by masses of boulder-clay, showing that severe glacial conditions had come on

after the existence of the mollusca contained in these beds. Such older shelly strata have been found in the southern part of the Isle of Arran, in Cantyre, in Lanarkshire, and other places. In Ayrshire Mr. John Smith has traced them all over the county and at all heights up to 1061 feet. Now on the east side of Scotland we have several examples of these older shell-beds, but it seems to me we have absolutely none corresponding to the later so-called Clyde beds. So far, however, as I am aware this absence of representatives of the Clyde beds on the east side of Scotland has not hitherto been distinctly asserted by anyone, and no doubt this opinion of mine may be disputed. Nevertheless, I think a due consideration should convince anyone who is well acquainted with the shell-beds of the two sides of the country that examples of the later series or so-called Clyde beds really do not exist on the east coast. Nothing like them has turned up on the shores of the Firth of Forth, where, if anywhere, we might expect them to be found. Neither are they to be seen along the Firth of Tay or the Moray Firth. It is true that instances of Arctic shell-beds have been met with at Elie in Fife, and at Errol on the Firth of Tay, but they evidently belong to an earlier submergence, and the Rev. Thos. Brown, who carefully examined these deposits and described them in the Transactions of the Royal Society of Edinburgh for 1867, clearly distinguishes them from the Clyde beds and assigns them, correctly as I think, to an earlier period. The group of mollusca contained in them comprises fewer species, is of a more intensely Arctic or even circumpolar character, and also indicates a greater depth of water. Moreover, the strata at Elie, Tyrie, and Portobello show evidence of disturbance, having been thrown into convolutions by the action of some powerful force such as the pressure of land-ice, a feature not observable in the later Clyde beds. These were formed apparently when the last great mantle of ice had passed or was just passing away, whereas the older shell-beds belong to an earlier time previous to this glaciation, but subsequent to an older and still greater one. Loch Lomond was at one time a salt-water fiord inhabited by Arctic mollusca belonging to the earlier stage. The shell-beds of that time were then demolished by the later ice coming down the basin, and their remains turned out into the ground beyond. The broken shells may be detected in the railway cuttings between Drymen and Gartness, where I observed them in 1864, both in beds of gravel and in coarse stony mud. Mr. Jack, who afterwards mapped the locality for the Geological Survey, traced a shelly boulder-clay over much of the ground at the south-east corner of the lake, and he attributes the occurrence of the broken shells in the clay to the action of a glacier coming down the bed of the lake and scouring out the marine beds beneath it, an opinion in which I quite agree with him. A great stream of ice had come down Loch Lomond and another down the line of the Forth. These were separated by the mountain ridge running from Ben Lomond towards Balfron, and in the lee of this ridge there are partially stratified masses of clay, sand, and gravel, which seem to have been left there owing to their sheltered position

having saved them from being swept away by the ice. Mr. Jack thinks that these beds were deposited during what he terms 'the great submergence,' but he makes out this submergence to have taken place at a period after the shelly till on the Endrick was formed. This is a point, however, in which I am unable to agree with him. Some of the sand, gravel, and stony mud was probably heaped up by the flank of the glacier which produced the shelly till, and about the same time, but the finer stratified beds of clay and sand near Balfron, I think, are just those portions of the glacial marine beds which escaped destruction owing to their sheltered position behind the ridge separating the two ice streams. The Forth glacier must have gone far eastward, but during its final retreat it has left at the Loch of Menteith a fine group of moraines which show no sign of having ever been submerged by any subsequent change of level, although their base is only about 50 feet above reach of the tide. I am, therefore, decidedly of opinion that no great submergence has taken place since the advance of the glaciers which produced the shelly boulder-clay on the Endrick at the south-east corner of Loch Lomond. But after these glaciers vanished, Loch Lomond (which is only 23 feet above the present sea-level) appears to have again become a salt-water creek inhabited by the later group of northern mollusca, whose shells, not crushed and broken, but entire and undemolished by any subsequent glacier, are still to be found in the present bed of the lake at the island of Inchlonaig and other places, where they had no shelter and where they could not have escaped destruction by such an agency.[1]

Here, then, we have evidence of two distinct deposits of marine beds separated by an interval of land-ice, and it is to this second and lesser submergence that I would assign what we may for convenience call the Clyde beds, although they are by no means confined to the Clyde basin, but are met with in a multitude of places along the west coast and its numerous creeks. The lowest height of the watershed between the Forth and Clyde is 160 feet near Kilsyth, and 220 near Balfron on the line of the Stirling and Balloch Railway. The submergence which led to the formation of the later Arctic shell-beds would therefore not extend across the watershed nor reach so far up, 50 or 60 feet being about the upper limit of these beds in the Clyde district, and the group of mollusca whose remains are found in them does not indicate much depth of water.

When I first made my acquaintance with the Clyde beds more than 40 years ago, I was struck with the abundance of the shells, their fine preservation, and the multitude of places in which they occur, all so unlike what I had experienced on the east side of the Kingdom. But I felt at a loss to understand how there should be such a difference between the two sides of the country, and it was not until long after that I came to perceive what I now take to be the true meaning of it all.

[1] See J. Adamson, in Wernerian Soc. Memoirs, vol. iv, p. 334; also Palæontographical Soc., vol. xxviii, p. 42.

The first thing that led me to suspect how the matter stood was the discovery of the older beds on the west coast, and the mode in which they generally presented themselves, for I then began to see that these were the true equivalents of our east coast ones, and that the reason of the great difference between them and the later Clyde beds was mainly that the latter had never been exposed to the same treatment. They had escaped the destructive action of the last glaciation and belonged to a newer stage. Hence the better preservation of the beds, the greater abundance of the fossils, and the more perfect state in which the shells are found.

The red clay in which Arctic shells (generally broken) have been got at Belhelvie and other places on the Aberdeenshire coast, can be shown to be of earlier date than the last glaciation, seeing that it is covered by the gravelly moraines of the last stream of ice which came down to the coast along the valleys of the Dee and Don. Agassiz, who visited these gravel hills along with Dr. Fleming in 1840, was confident they were moraines, while Fleming was equally satisfied that their formation was posterior to the shell-bearing clay beside them, seeing that they not only lie above the clay, but also occasionally contain rolled masses of it (see "Lithology of Edinburgh," p. 82), all which I can confirm. This reddish clay of the east midland coast of Scotland contains not only Arctic shells occasionally, but also bits of chalk, which are sometimes well scratched and rubbed as if by ice. These chalk fragments were probably brought to our shores by the Scandinavian ice which passed over and destroyed some of the Danish chalk. They are by no means uncommon at Belhelvie and Montrose, and occur also at Barry, Portobello, and Peterhead. There is, therefore, some reason to believe that all these clays of the east midland coast of Scotland which contain Arctic shells and bits of chalk belong to approximately one and the same period — a period previous to the last general glaciation, and consequently earlier than the later Clyde beds, with which they should not be confounded.

Now if I am right as to the absence of the later Arctic shell-beds on the east side of Scotland, how are we to account for it? It seems to me that it might be simply the result of the unequal pressure of ice on the two sides of the kingdom, the heavy load on the west causing a depression and submergence which did not affect the east side. Indeed, the tendency there would rather be to a rise owing to the reason previously mentioned.

In my paper on the Parallel Roads of Glen Roy in 1863, I drew particular attention to the evidence of extreme glaciation along the west coast, and I suggested that as the rainfall there far exceeds that of the east, so in former times the fall of snow would be in like excess, hence heavier ice would result. The rainfall along the west of Scotland is two or three times what it is on the east, while on the mountains the excess is far greater. The annual average measured by the rain-gauge on the top of Ben Nevis for the nineteen years ending 1903 is no less than 160 inches, while at Fort William, close to the bottom of the hill, it is not more than 78 inches, or just

about half. On the east coast of Scotland it is scarcely 30 inches. When we consider how the ice grows upon heavily snowed regions, owing to the continual storage from year to year, we may easily imagine what an enormous excess must have resulted on the west side of Scotland. In fact, we know this from the state of matters that existed in Inverness-shire just before the glacier lake of Glen Roy was formed, when the western ice overflowed all the passes on the east side of the Great Glen, although these passes are actually higher than those on the west, which led out to the Atlantic. This difference between the two sides of the country in regard to the amount of ice that lay upon them has never been adequately realized, although it affords the only true means of explaining many remarkable features in the character of the surface, and I think it might be sufficient to account for that depression of the western side which led to the formation of the Clyde beds.

III. — Further Note on *Cyclus Johnsoni*, from the Coal-measures near Dudley.

By Henry Woodward, LL.D., F.R.S., V.P.Z.S., F.G.S.

My friend Professor Lapworth kindly sent me, for identification, in July last the split portions of two nodules containing examples of the interesting little Crustacean genus *Cyclus*, from the 'Pennystone' Ironstone of the Coal-measures near Dudley, obtained by Miss Ethel M. R. Wood, M.Sc., of the University of Birmingham, and I have obtained permission to publish a note thereon, supplementary to my paper in 1894.[1] In that paper I described, among other species, one which I named *Cyclus Johnsoni* (op. cit., Pl. XV, Figs. 4–7, pp. 537–538), from the Coal-measures, Coseley, near Dudley, which is identical with Miss Wood's specimens. As one of these latter displays some further details of appendages I have given a figure of it here as tending better to elucidate the structure of this curious genus. (See Woodcut on p. 491.)

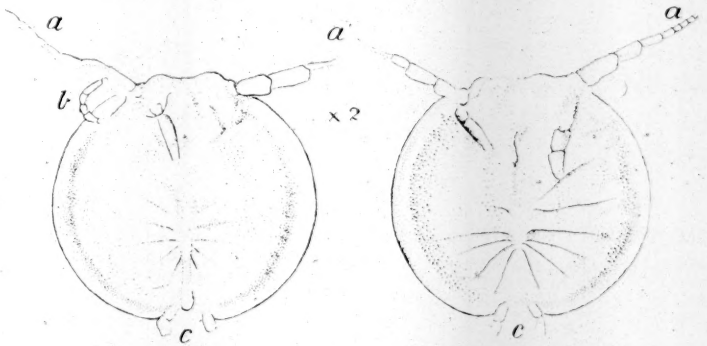
This specimen shows the broad, raised, and grooved margin of the shield- or disc-like carapace, the centre of which is removed and displays, as in *Cyclus Rankini* (op. cit., Pl. XV, Fig. 8), the radiating ridges of the ventral or sternal arches once giving attachment to seven or more pairs of simple swimming- or walking-feet, each having been no doubt furnished with an endopodite and exopodite, as in the limbs of Trilobites,[2] subserving the purposes of branchiæ and limbs, the bases being perhaps also maxillæ, or they may have been furnished with such simple appendages as are seen in the larval stages of modern *Limulus*.[3]

[1] See "Contributions to our Knowledge of the genus *Cyclus*, from the Carboniferous Formation of various British localities": Geol. Mag., 1894, pp. 530–539, Plate XV.

[2] C. D. Walcott: Geol. Mag., 1894, p. 246, Pl. VIII, Fig. 6. C. E. Beecher: Geol. Mag., 1896, p. 193, Pl. IX.

[3] See Mon. Brit. Foss. Crustacea, Order Merostomata, by H. Woodward, pt. v, pp. 214–218, pl. xxxiii and explanation: Pal. Soc. Mon., 1878.

Bearing in mind that *Prestwichia rotundata*, *P. Birtwelli*, and other Coal-measure forms of Xiphosura, apparently, are not more advanced in development, as compared with the living king-crab, than the later larval stages of *Limulus polyphemus* when first quitting the egg, as represented in our monograph above quoted, then, if we venture to assume that the curious forms referred to the genus *Cyclus* are but the larval stages of those Coal-measure *Limuli*, we may most certainly conclude that they would represent in point of structure the still earlier phases of *Limulus*, they having been, so to say, more precocious in quitting the egg than their modern representatives. For example, in the earlier stages of development of the fertilised egg in *Limulus polyphemus* (pl. xxxiii, figs. 1 and 2, op. cit.) only



Cyclus Johnsoni, H. Woodw., 1894.

Impression and counterpart of a specimen from the 'Pennystone' Ironstone band of the Coal-measures, Coseley, near Dudley. Drawn twice nat. size. *a*, *a*, antennæ; *b*, endopodite (?) of one of mouth-organs; *c*, *c*, appendages of the posterior segment of the body. (Original specimen in Birmingham University Museum.)

seven or eight pairs of simple limbs are seen, corresponding with a similar number of cephalic somites, partially united dorsally, the thoracico-abdominal segments and the short telson not being developed until a much later stage.

This early or premature hatching out of the young characterises the Phyllopoda, and indeed most living Entomostraca. In those Trilobites whose early history is known the young, as in *Sao*, *Ptychoparia*, *Triarthrus*, *Proetus*, *Acidaspis*, and *Dalmanites*, are almost as simple, or even more so, in their earliest known stages as *Cyclus* (see Beecher and Barrande's figures *infra*, p. 492).

It must, of course, be borne in mind that this is only a suggestion, and may hereafter prove to be of no value; still, the fact remains that the first considerable development of *Limulus*-like Crustaceans occurs in the Coal-measures, only one small form, *Neolimulus*, being met with earlier in the Upper Silurian of Lesmahagow. We may also justly assume that *Limuli* may be found in all those deposits younger than the Coal-measures, seeing that king-crabs are living at the present day widely distributed on the east coast of North

America, and in the seas of China, Japan, and Molucca; and they have already been met with fossil in the Jurassic, Cretaceous, and Tertiary strata.

Figs. 1–5.—Youngest larval or 'Protaspis' stage of some Trilobites (after Beecher[1]), for comparison with *Cyclus*.

Fig. 1.—*Sao hirsuta*, Barrande. Cambrian: Skrey, Bohemia.
,, 2.—*Ptychoparia Kingii*, Meek. Cambrian: North America.
,, 3.—*Proetus parviusculus*, Hall. Ordovician: New York, U.S.
,, 4.—*Dalmanites socialis*, Barr. Ordovician: Bohemia.
,, 5.—*Olenellus asaphoides*, Emmons, sp. Lower Cambrian (*Olenellus* zone).

IV.—Sedgwick Museum Notes.

New Fossils from the Haverfordwest District. V.

By F. R. Cowper Reed, M.A., F.G.S.

(PLATE XXIV.)

LAMELLIBRANCHIATA.

A FEW species of Lamellibranchs were recorded by Messrs. Marr and Roberts[2] from the *Trinucleus seticornis* Beds of Haverfordwest; and though some new species may now be added to their number with the aid of the numerous specimens collected by Mr. V. M. Turnbull, yet a complete list of the species is at present impossible owing partly to the imperfect condition of many of the fossils and partly to the unsatisfactory state of our knowledge of this class as developed in British Ordovician rocks.

The Slade and Redhill Beds have yielded the majority of the species, and the following may be enumerated:—

Redhill Beds.

Ctenodonta obliqua, Portl. (?).
,, *transversa*, Portl. (?).
,, *varicosa*, Salt. (?).
,, *sladensis*, sp. nov. (var.).
,, *subscitula*, sp. nov.
,, two sp. indet.
Arca (*Palearca*), sp. indet.
Cyrtodonta (?) *cancellata*, sp. nov.

Slade Beds.

Orthodesma semiradiata, sp. nov.
Ctenodonta lingualis, Phill. (?).
,, *sladensis*, sp. nov.
,, *transversa*, Portl. (?).
,, two sp. indet.

[1] Figs. 1–4, from Zittel's Textbook of Palæontology, translated and edited by C. R. Eastman (London, 1900; 8vo), p. 618. Fig. 5 from C. D. Walcott's Lower Cambrian Fauna, pl. lxxxviii, fig. 1.

[2] Marr & Roberts: Quart. Journ. Geol. Soc., vol. xli (1885), pp. 476–490.

Arca (*Palearca*) *Turnbulli*, sp. nov.
Whitella (?) *tantilis*, sp. nov.
Ambonychia cf. *radiata*, Hall.
Modiolopsis Martini, sp. nov.
,, *subgradata*, sp. nov.
,, sp. indet.
Goniophora cf. *cymbæformis*, Sow.

ORTHODESMA SEMIRADIATA, sp. nov. (Pl. XXIV, Figs. 8, 9, 10, 10*a*.)

DESCRIPTION.—Shell elongate-oval, narrow, about three times as long as high, gaping slightly at both ends; inferior and superior margins subparallel; beaks small, not prominent, scarcely rising above hinge-line, directed forwards, situated at about one-fourth or one-fifth the length of the shell from the anterior end, with small indistinctly defined lunulate area in front of them; anterior end of shell short, narrowed, acutely rounded; posterior end obliquely truncated with inferior angle subacutely rounded; cardinal margin straight, about one-half to two-thirds the length of the shell; inferior margin gently arcuate, curving up sharply in front. Valves compressed, very slightly convex, with weak, rounded, umbonal ridge running obliquely backward from beak towards postero-inferior angle, before reaching which it becomes obsolete; surface of valve flattened above umbonal ridge; no distinct medial depression present. Surface of valves ornamented with sharp, concentric, subequal lines and striæ, well marked in front of umbonal ridge, behind which they are nearly obsolete; umbonal ridge and post-umbonal surface marked with fine, low, closely placed, rounded radii, most distinct near inferior angle. Anterior adductor impression submarginal, ovate, more or less distinct; posterior adductor and pallial impression not visible. Shell apparently thin.

DIMENSIONS.

	I.	II.	III.	IV.	V.
Length	26·5	32·5	23·5	19·0	29·0 mm.
Height (at beak)	6·5	12·5	8·5	4·5	7·5 mm.
Distance of beak from anterior end	6·0	—	—	—	—

HORIZON AND LOCALITY.—Slade Beds: roadside near St. Martin's Cemetery, Haverfordwest.

REMARKS.—This species is fairly common in the Slade Beds, near St. Martin's Cemetery, Haverfordwest, a locality at which many Lamellibranchs are found. The specimens are frequently somewhat distorted and crushed, and suggest a thin delicate shell. The true generic position of this shell is somewhat doubtful, since we are ignorant of its hinge-characters, and since the classification and nomenclature of the Lower Palæozoic Lamellibranchs is in a notoriously unsatisfactory and unsettled condition. Ulrich[1] has recently revised the members of this group occurring in the Ordovician beds of Minnesota, but his diagnoses are not always easy to apply to the

[1] Ulrich, Lower Silur. Lamell. Minnesota: Geol. Surv. Minnes., vol. iii, pt. 1, 1895, pp. 475–628.

poorly preserved material from the British formations, and consequently the new or revised generic terminology adopted by him cannot in many cases be employed without some element of uncertainty.

In the present case there are three genera which have some external points of resemblance to this Slade form. *Orthodesma* resembles our shell in general shape, the gaping of both ends, and the position of the beaks and muscles, but it is stated to have a broad mesial sulcus which is certainly absent in the Slade species. On the other hand, *O. canaliculatum*, Ulrich,[1] has only a very shallow sulcus, and possesses obscure posterior radii, a kind of ornamentation apparently wanting in other members. *O. minnesotense*, Ulrich,[2] also appears to be allied to our form, judging from the figures and description; the shape of the shell is nearly identical, and the mesial sulcus appears to be absent. *Endodesma*[3] has a more or less defined lunule in front of the beaks, but the mesial depression is strong and the basal margin consequently sinuate; however, the general external aspect of some species is not very dissimilar from *Orthodesma*. *Whitearesia* (= *Actinomya*)[4] has tightly closing valves and no lunule, but a radial ornamentation on the surface of the shell is sometimes well marked.

On the whole, of the above three genera our species seems most probably to belong to *Orthodesma*. The external ornamentation recalls *Nuculites poststriatus*, Emmons,[5] of the Trenton and Hudson River groups, but the shell is much shorter and higher, the beaks are subanterior, and the umbonal ridge stronger and more prominent. *Modiolopsis postlineata*, McCoy,[6] with a similar ornamentation, is a shorter shell, with almost terminal beaks and a more abruptly truncated posterior end, but the type is imperfect, and it may be allied to this new Slade species.

CTENODONTA SLADENSIS, sp. nov. (Pl. XXIV, Fig. 12.)

DESCRIPTION.—Shell subquadrate-ovate or subrhomboidal, about one and a half times as long as high, thin, compressed; anterior end rounded; posterior end obliquely truncate above, rounded below, meeting hinge-line at about 45°; inferior margin broadly rounded; cardinal margin behind beaks straight and about half the length of shell; beaks small, not prominent, directed forwards, situated at about one-third the length of the shell from anterior end, which is slightly excavated below them. Umbonal ridge sharply marked, slightly arched; cardinal slope above it flattened, compressed. Teeth behind beak obliquely inclined, transverse, 10 or more in number. Surface of shell regularly marked with very fine concentric striæ.

[1] Ulrich: op. cit., p. 520, pl. xxxvii, figs. 7–11.
[2] Ulrich: op. cit., p. 517, pl. xxxvii, figs. 12–14.
[3] Ulrich: op. cit., p. 525.
[4] Ulrich: op. cit., pp. 513, 628.
[5] Emmons: Geol. Rep., 1842, p. 399, fig. 3. Hall: Palæont. New York, vol. i, pp. 151, 301, pl. xxxiv, figs. 2*a*, *b*; pl. lxxxii, figs. 10*a*, *b*.
[6] McCoy: Synops. Palæoz. Foss. Woodw. Mus., p. 268, pl. ii, fig. 22.

Dimensions.

	I (from Slade Beds).	II (var. from Redhill Beds).
Length	13·5	14·0 mm.
Height	10·0	9·5 mm.

Locality and Horizon.—Slade Beds: roadside 110 yards west of St. Martin's Cemetery; (variety) Redhill Stage, Prendergast Mill Lane.

Remarks. — This shell has a very compressed form, and its subquadrate shape and subauriculate appearance give it a considerable similarity to *Nucula deltoidea*, Phillips.[1] But the latter is less obliquely truncated behind, the umbonal ridge is less sharply marked, and the teeth appear to be more numerous. Ulrich's *C. Calvini*[2] is apparently more allied. The Redhill specimens are rather more ovate than those from the Slade Beds, and have the teeth generally better preserved.

Ctenodonta subscitula, sp. nov. (Pl. XXIV, Figs. 13, 13*a*.)

Description.—Shell elongate-ovate, about twice as long as high, highest at beaks, narrowed posteriorly, strongly convex, most so about middle, somewhat compressed behind. Anterior end broadly rounded, excavated above in front of beaks; posterior end produced, subacutely pointed, very obliquely truncated above; inferior margin moderately convex. Hinge-line gently arcuate, with series of about 22 small transverse, slightly oblique teeth in front of beaks, increasing somewhat in size towards the front and extending from beaks to anterior end of shell; post-umbonal series of teeth meeting anterior series at very obtuse angle, but continuous with it and consisting of 9–11 larger transverse teeth increasing rapidly in size posteriorly and successively becoming more obliquely inclined. Beaks prominent, incurved, rising above hinge-line, scarcely bent backwards, situated at about one-third the length of the shell from anterior end. Surface of valves convex, with strong, subangular, curved, diagonal ridge running back from beak to upper posterior angle, limiting a more or less excavated cardinal slope inclined at nearly a right angle to the general convex surface of the valve. Surface of shell marked with regular, equidistant, rather strong, concentric striæ.

Dimensions.

	I.	II.
Length	16·5 ...	13·5 mm.
Height	9·0 ...	7·0 mm.

Horizon and Locality. — Redhill Beds: Prendergast Place and Lane.

Remarks.—The characters of the dental series combined with the shape and general features of the shell distinguish it from the other numerous species of *Ctenodonta* found in the Redhill and Slade Beds, and I am not acquainted with any described species which can be

[1] Phillips: Mem. Geol. Surv., vol. ii, pt. 1, p. 366, pl. xxii, fig. 5.
[2] Ulrich: op. cit., p. 596, pl. xlii, figs. 61–64.

considered identical with it. McCoy's so-called *Arca scitula*[1] bears a considerable external resemblance to our Redhill form, but no information as to the internal characters of this Irish shell has been published.

Arca (Palæarca) Turnbulli, sp. nov. (Pl. XXIV, Fig. 14.)

Description.—Shell oblong, more than twice as long as high; convex, most so about middle; hinge-line straight, about three-fourths the length of shell; beaks broad, obtuse, directed forward, rising above hinge-line, incurved, situated at about one-fourth the length of hinge-line from front end, and at about one-third to two-fifths the length of shell; anterior end of shell obliquely truncate above, acutely rounded at inferior angle; inferior margin slightly arcuate; posterior end obtuse, abruptly truncate, not produced, meeting hinge-line at about 60°–70°. Teeth transverse, inclined away from beak, about 8–10 visible behind beak. Surface of valves moderately convex with umbonal ridge running obliquely back to posterior end at angle of about 20° to hinge-line; cardinal slope behind and above umbonal ridge compressed, flattened; anterior end in front of beaks somewhat depressed above, but convex below. Surface of shell marked with fine concentric striæ and weak growth-wrinkles.

Dimensions.

Length	20·5 mm.
Height	9·5 mm.

Locality and Horizon.—Slade Beds: roadside 150 yards west of St. Martin's Cemetery, Haverfordwest.

Remarks.—This species resembles *A. edmondiformis*,[2] but the shell is relatively longer, the beaks are more central, and the truncation of the ends is different. Portlock's *Arca cylindrica*[3] is more elongated and the beaks more anterior; and in his *A. subtruncata*[4] the shell is shorter and broader, and the beaks are more centrally situated.

Cyrtodonta (?) cancellata, sp. nov. (Pl. XXIV, Figs. 11, 11*a*.)

Description.—Shell quadrato-ovate, slightly oblique, truncated abruptly in front, broadly rounded behind, about $1\frac{1}{4}$ times as long as high, widening a little posteriorly; surface moderately convex, most so about middle of valves. Beaks anterior, low, small, scarcely rising above hinge-line, directed forwards. Anterior margin nearly straight, abrupt, meeting inferior and superior margins at nearly right angles. Inferior margin slightly arcuate. Posterior end obtuse, broadly rounded below, obliquely truncate above. Superior cardinal margin straight, about three-fourths the length of shell. Hinge-line bent at nearly a right angle at beaks. Broad, rounded, ill-defined umbonal ridge running obliquely from beak to posterior

[1] McCoy: Synops. Silur. Foss. Irel., p. 20, pl. ii, fig. 6.
[2] McCoy: Synops. Brit. Pal. Foss. Woodw. Mus., p. 283, pl. ix, figs. 2, 3.
[3] Portlock: Geol. Rep. Londond., p. 428, pl. xxxiv, fig. 9.
[4] Ibid., p. 427, pl. xxxiv, fig. 1.

angle, increasing in height to middle, then decreasing behind and merging into general convexity of valve. Surface of shell ornamented with numerous fine, regular, equidistant, straight, radiating, raised lines running from beak to inferior margin on anterior two-thirds of shell, but faint or absent on posterior portion; crossed by rather irregular, somewhat undulating, not always equidistant, fine concentric fimbriations which become much more numerous and regular on posterior third of shell where the radii are absent.

DIMENSIONS.

Length	9·0 mm.
Height	7·0 mm.
Thickness (one valve)	3·5 mm.

HORIZON AND LOCALITY. — Redhill Beds: 80 yards north of Prendergast Place, Haverfordwest.

REMARKS.—The true generic position of this pretty little shell is somewhat doubtful, for though we have the internal cast of the shell and external imprints of the surface, the cardinal portion is not well preserved, and the region near the beaks is somewhat abraded. No trace of teeth is visible, but the ligament seems to be external behind the beaks. I am inclined to associate it with *Cyrtodonta*, some species of which bear much resemblance in external shape, though the ornamentation in our specimens is peculiar.

WHITELLA (?) INUTILIS, sp. nov. (Pl. XXIV, Figs. 7, 7*a*.)

DESCRIPTION.—Shell small, oblique, very elongate-ovate, somewhat wedge-shaped, narrowing posteriorly; strongly ventricose and inflated. Hinge-line short, straight behind beaks, and less than one-third the oblique length of the shell, meeting posterior margin at angle of about 135°, with elongate narrow escutcheon grooved on each side for reception of ligament. Posterior end of shell much produced, very obliquely truncated, margin nearly straight, with inferior angle acutely rounded; inferior margin slightly arcuate, inclined to posterior margin at about 30°–40°; anterior end of shell very short, rounded. Beaks rather prominent, small, acute, directed forward, rising above hinge-line, incurved, situated at about one-third the length of hinge-line. Strongly elevated, subangular umbonal ridge, slightly arched upwards, running from beak to posterior basal angle, nearer upper than lower margin of shell, giving valves an inflated appearance; convexity of ridge increasing from beak to middle of valve and then decreasing gradually to extremity. Surface of shell marked with rather strong concentric striæ and wrinkles, and by a few faint, gently curved, radiating striæ, especially distinct on the region anterior to the umbonal ridge.

DIMENSIONS.

Length	15·0 mm.
Height	8·0 mm.
Thickness	6·5 mm.

HORIZON AND LOCALITY.—Slade Beds: roadside near St. Martin's Cemetery, Haverfordwest.

Remarks.—The true generic position of this little shell (of which I have seen only one well-preserved specimen) is somewhat difficult to decide. At first I was inclined to put it in *Goniophora*, though that genus is typically Silurian. But on comparison with the description and figures of the American genus *Whitella*[1] from the Ordovician of Ohio, Minnesota, etc., the shape, the presence of the strong umbonal ridge and escutcheon lead me to associate it preferably with the latter genus. *Wh. sterlingensis*, Meek & Worthen,[2] and *Wh. præcipta*, Ulr.,[3] are species which may be compared with it.

Ambonychia (Byssonychia) cf. radiata, Hall.

There is one fragmentary cast of a large Lamellibranch from the Slade Beds in Mr. Turnbull's collection which may be compared with Hall's *Ambonychia radiata*[4] from the Hudson River group. The umbonal portions of both valves in juxtaposition are preserved as internal casts, and there is also the imprint of the exterior of one valve. The ventricose shape of the valves, the pointed incurved beaks, and the regular, low, radiating plications, 30–40 in number, ornamenting the surface, can be distinctly seen, but no other structural features are distinguishable. The fragment which represents the anterior portion of the shell measures about 27 mm. in length, but the shell when complete must have been about twice this length. The occurrence of this specimen is worth noting, as no example of a Lamellibranch resembling *A. radiata* has been previously recorded from the Slade Beds; but it is to be hoped that better material for description will be subsequently obtained. The species has been found in the Corona Beds of Cross Fell. It may be mentioned that Ulrich[5] has put *A. radiata* into a new genus *Byssonychia*, separating it from the typical *Ambonychia bellistriata*, Hall.

Modiolopsis Martini, sp. nov. (Pl. XXIV, Figs. 1–4.)

Description. — Shell small, obliquely elongate, expanding posteriorly, convex. Cardinal margin straight; anterior end small, narrowed, rounded; beaks small, obtuse, incurved, moderately prominent, situated at about one-fifth or one-sixth the length of the shell from anterior end; inferior margin gently sinuated at about one-third or one-fourth of its length, curving round gently at posterior extremity; posterior end of shell broad, nearly twice as wide as anterior end, strongly rounded. Valves convex, more or less ventricose, with indefinite rounded, broad, umbonal ridge running obliquely back from beak; shallow indistinct sulcus running from beak in front of umbonal ridge to inferior margin, which it slightly sinuates; surface of valves behind umbonal ridge more or less flattened. Surface of shell ornamented with fine concentric growth-lines and striæ, some of which are stronger than others.

[1] Ulrich: op. cit., p. 564.
[2] Ulrich: op. cit., p. 567, pl. xli, figs. 27, 28.
[3] Ulrich: op. cit., p. 574, pl. xli, figs. 15, 16.
[4] Hall: Palæont. New York, vol. i (1847), p. 292, pl. lxxx, figs. 4*a*–*l*.
[5] Ulrich: op. cit., p. 498.

Dimensions.

	I.		II.
Length	15·0	...	15·0 mm.
Height at beak	4·5	...	5·0 mm.
Height at posterior end	7·5	...	7·0 mm.

Horizon and Locality.—Slade Beds: roadside near St. Martin's Cemetery, Haverfordwest.

Remarks.—The above described species varies somewhat in its proportions, but is certainly distinct from the British species previously described from Ordovician rocks which can be referred to the genus *Modiolopsis* in the restricted sense in which the term is used by Ulrich (op. cit., p. 502). The definition given by him is the following:—"Shell more or less elongate, usually subovate, widest posteriorly; valves moderately ventricose, closing tightly all around. Beaks small, near the anterior extremity; umbones depressed by a flattening or depression which crosses the valves obliquely, and widening causes a straightening or sinuation of the basal outline. Hinge of moderate strength, rarely straight, generally somewhat arcuate, without well-marked teeth; an obscure oblique thickening beneath the beak of one valve and a corresponding depression in the other occasionally distinguishable. Ligaments linear, external and internal, chiefly the former. Anterior adductor impression subovate, large, deep, sharply defined on the inner side, occupying the greater part of the small anterior end. Posterior scar very faintly impressed, large, subcircular, situated near the centre of the posterior third of the cardinal slope. Palliat line simple. Anterior pedal muscle forming a minute pit in the under side of the hinge-plate beneath the beak. Posterior pedal muscles large, attached just above and in front of the adductor. Type: *M. modiolaris*, Conrad, sp."

The Slade species appears to be allied to *M. arguta*, Ulrich (op. cit., p. 506, pl. xxxvi, figs. 3–6), and *M. nana*, Ulrich (op. cit., p. 507, pl. xxxvi, fig. 7), from the Trenton and Galena Shales. The British shells attributed to *M. modiolaris*, Conr., and *M. Nilsoni*, His., sp., are much shorter and higher, and have a broader anterior end. Salter's *Mytilus gradatus*[1] is likewise a less elongated form. Portlock's *Modiola expansa*[2] from Desertcreat is allied, but undoubtedly distinct from our species.

There is a variety of *M. Martini* occurring in association with the typical form, and scarcely separable from it specifically; it is characterised by possessing a less elongated shape, a smaller widening of the posterior end, a somewhat broader anterior extremity, and rather stronger varices of growth on the surface. The specimens are mostly not well preserved, and intermediate forms connecting it with the type are not uncommon. Some specimens resemble the longer forms of *M. gradata*, Salter (op. cit., figs. 3 and 4), but the latter occurs in the Ludlow Beds, and is probably distinct.

[1] Salter: Mem. Geol. Surv., vol. ii, pt. 1, p. 363, pl. xx, figs. 3–5.
[2] Portlock: Geol. Rep. Londond., p. 425, pl. xxxiii, fig. 6.

Modiolopsis subgradata, sp. nov. (Pl. XXIV, Figs. 5, 6.)

Description. — Shell subquadrate to transversely ovate, short, oblique, widening posteriorly, about 1¾ to 1⅞ times as long as high; greatest height at about two-thirds of its length. Hinge-line straight, extending about two-thirds the length of the shell behind the beaks. Anterior end of shell somewhat narrowed, subtruncate, rounded, about two-thirds the greatest height of the shell. Inferior margin slightly convex, oblique, gently sinuated. Posterior end broadly rounded, regularly convex; inferior angle not produced. Beaks situated at about one-third the length of the shell from anterior extremity, small, obtuse, rising a little above hinge-line. Surface of valves gently convex, with a more or less developed rounded umbonal ridge traversing valve; cardinal slope somewhat flattened; mesial depression faint or nearly obsolete, but always indicated on inferior margin by sinuation of edge. Surface of shell marked with concentric striæ and a few stronger growth-ridges, meeting hinge-line at an angle between 75° and 90°.

Dimensions.

	I.	II.	III.
Length	10·5	9·0 ...	14·5 mm.
Maximum height ...	8·0	7·5 ...	10·0 mm.

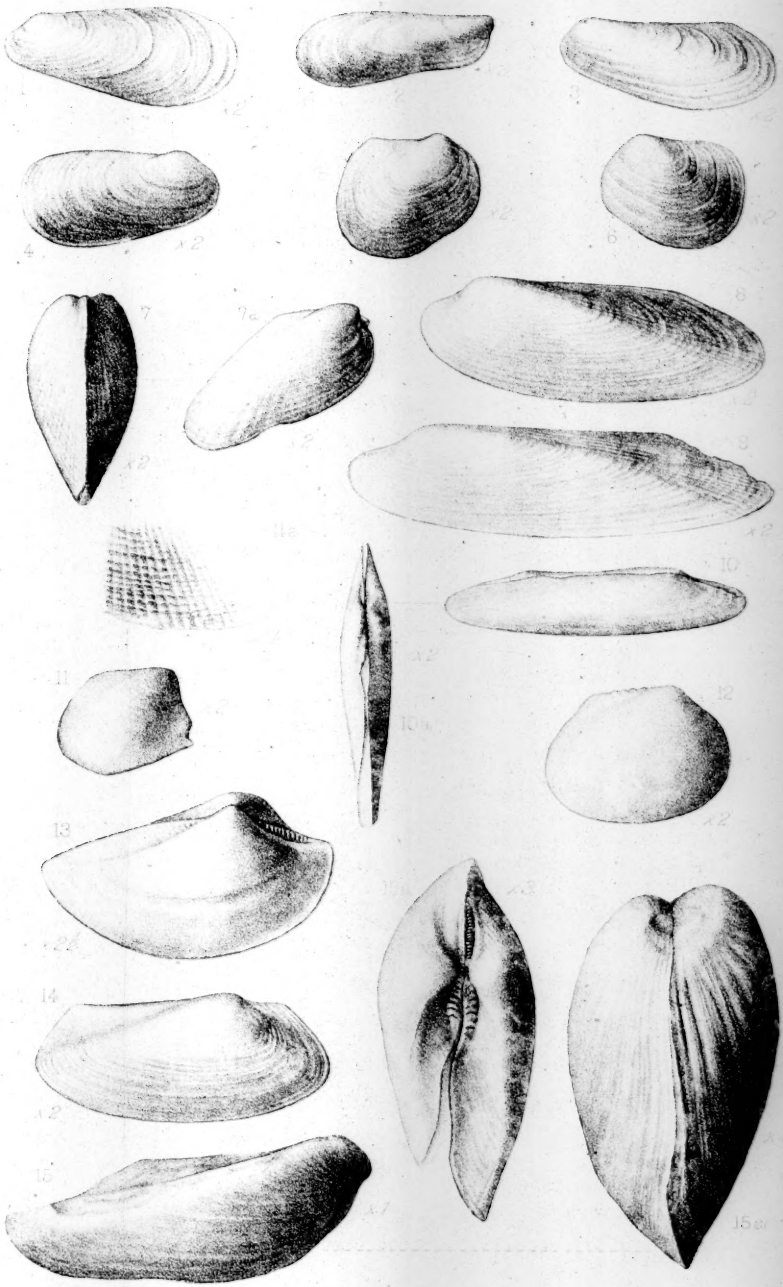
Horizon and Locality.—Slade Beds: roadside near St. Martin's Cemetery, Haverfordwest.

Remarks.—The short, broad, subquadrate shape of this species, especially emphasised in the younger and smaller specimens, recalls both *M. gradata*, Salt.,[1] and *M. quadrata*, Salt.,[2] but the hinge-line is longer and the inferior angle not produced as in the former, while the latter has a less oblique shape, the inferior margin is not sinuated, and the anterior end less narrowed.

Goniophora cf. cymbæformis (Sow.). (Pl. XXIV, Figs. 15, 15*a*.)

There is a large Lamellibranch from the Slade Beds which bears a great resemblance to *Goniophora cymbæformis* (Sow.), but this species typically belongs to a much higher horizon (i.e. Ludlow). Our single Slade specimen, which measures 52 mm. in length, 23 mm. in height, and 29 mm. in depth, has the peculiar elongated form with very deep valves, incurved anterior beaks, strong angular umbonal ridge, pointed extremity, and large flattened cardinal region and posterior side inclined at an angle of 45°–60° to the general convex surface of the shell. The beaks are small, but acute, and have a distinct cordate, slightly depressed lunule below them. Below the umbonal ridge the valve is rounded and convex, and the shell is marked with concentric striæ and rugæ, the latter being strongest and most regular near the beaks and on the anterior part of the umbonal ridge. The much flattened elongate cardinal slope is only marked with fine concentric striæ, the sudden change in the character

[1] Salter: Mem. Geol. Surv., vol. ii, pt. 1, p. 363, pl. xx, figs. 3–5.
[2] Ibid., p. 363, pl. xx, fig. 1.



S. M. Woodward del et lith. West, Newman imp.

Lamellibranchs from Haverfordwest.

of the ornamentation being conspicuous. Our specimen is undoubtedly somewhat compressed and distorted, but its close relations or perhaps identity with the Silurian species *G. cymbæformis* cannot be disputed. Sowerby's[1] description of the Upper Ludlow shell is as follows:—"Transversely oblong; valves deep, carinated; the keel acute, extending from the beak to the angular extremity of the narrow, oblique, produced posterior side; beaks short, incurved, close to the small heart-shaped anterior side."

EXPLANATION OF PLATE XXIV.

FIG. 1.—*Modiolopsis Martini*, sp. nov. Slade Beds: near St. Martin's Cemetery, Haverfordwest. × 2.
,, 2.—Ditto. Same horizon and locality. × 2.
,, 3.—Ditto. Same horizon and locality. × 2.
,, 4.—Ditto. Same horizon and locality. × 2.
,, 5.—*Modiolopsis subgradata*, sp. nov. Same horizon and locality. × 2.
,, 6.—Ditto. Same horizon and locality. × 2.
,, 7.—*Whitella* (?) *inutilis*, sp. nov. Internal cast, interior view. Same horizon and locality. × 2.
,, 7*a*.—Ditto. Same specimen, side view. × 2.
,, 8.—*Orthodesma semiradiata*, sp. nov. Same horizon and locality. × 2.
,, 9.—Ditto. Same horizon and locality. × 2.
,, 10.—Ditto. Same horizon and locality. × 2.
,, 10*a*.—Ditto. Same specimen, cardinal view, showing gaping extremities of shell. × 2.
,, 11.—*Cyrtodonta* (?) *cancellata*, sp. nov. Internal cast. Redhill Beds: Prendergast Place, Haverfordwest. × 2.
,, 11*a*.—Ditto. Same specimen. Portion of exterior of right valve, showing ornamentation. × 4.
,, 12.—*Ctenodonta sladensis*, sp. nov. Internal cast. Slade Beds: near St. Martin's Cemetery, Haverfordwest. × 2.
,, 13.—*Ctenodonta subscitula*, sp. nov. Internal cast. Redhill Beds: Prendergast Place, Haverfordwest. × 2½.
,, 13*a*.—Ditto. Same specimen, showing cardinal characters. × 3.
,, 14.—*Arca* (*Palæarca*) *Turnbulli*, sp. nov. Slade Beds: near St. Martin's Cemetery, Haverfordwest. × 2.
,, 15.—*Goniophora* cf. *cymbæformis* (Sow.). Same horizon and locality. Nat. size.
,, 15*a*.—Ditto. Same specimen, interior view. Nat. size.

V.—Rodents from the Pleistocene of the Western Mediterranean Region.

By Dr. C. I. Forsyth Major, F.Z.S.

(*Concluded from the October Number, p.* 467.)

Nice.—Among the mammalian remains enumerated by Risso from the bone breccia of the Castle Catinat at Nice, are bones and teeth of '*Lagomys*.'[2] Remains of the same genus have been more recently mentioned by Rivière, from a palæolithic deposit discovered by him in a small cave, Lympia, inside the town of Nice.[3]

Mentone. — On pl. xvii ("Faune des grottes de Menton"),

[1] Sowerby, in Murchison's Silur. Syst., p. 609, pl. v, fig. 6.
[2] A. Risso, Hist. Natur. des princ. prod. de l'Europe mérid., vol. i, pp. 151, 152 (1826).
[3] E. Rivière, "La Grotte Lympia": C. R. Paris, vol. xciv, p. 1264 (1882).

fig. 10, of Rivière's well-known publication,[1] is represented a left mandibular ramus of a "*Lagomys* d'assez petite taille," according to the explanation of the plate. In the dimensions, which are by no means small for a member of the family, as well as in the contours of the ramus, it corresponds with the *Prolagus* from Corsica; it certainly belongs to the latter genus, and not to the recent *Ogotona* (*Lagomys*). The text makes no mention of this rodent as occurring in the caves of Mentone, so that further confirmation seemed desirable. This has now been obtained in the most satisfactory manner, Professor Boule having found *Prolagus* in the "Grotte du Prince," near Mentone. In his preliminary notice on the results of the excavations,[2] this rodent is stated to occur together with the rabbit, etc., in strata underlying an Upper Quaternary fauna (*Rhinoceros tichorhinus*, reindeer, ibex, marmot, etc.), and resting on deposits containing a Lower Quaternary fauna (*Elephas antiquus, Rhinoceros Mercki, Hippopotamus*).

The question as to the specific identity of all these remains of *Prolagus* from different localities must be left to future investigation; the evidence from some of the continental deposits is for the present so scanty that it is only just sufficient to ensure the generic determination, even that remaining still somewhat doubtful with regard to *Lagomys* from the Nice deposits.

From the discovery of *Prolagus* at Barcelona, Depéret inferred a continental origin of the Corsican and Sardinian forms. "Il est dès maintenant facile de suivre l'émigration géologique de ce rongeur depuis le Pliocène de Perpignan, en passant par le Quaternaire ancien de Barcelone, jusqu'au Quaternaire récent de Corse et Sardaigne."[3] It remains, however, to be seen whether all the insular Pleistocene deposits containing the *Prolagus* belong to the upper and all the continental to the lower stage of that period. It is also to be borne in mind that not all of the latter deposits seem to have been continental in origin. All of them, from Gibraltar to Mentone, are on or near the seashore; some of the bone breccias, e.g., Gibraltar, Antibes, Cette, being situated on promontories, which have only recently become connected, or more probably reconnected, with the adjacent continent, and, as in the case of the more eastern ones, may have been part of Corsica, or rather of the 'Tyrrhenis,' to use a term which implies a larger area.

Depéret assumes that the *Prolagus* did not exist in Corsica and Sardinia before recent Pleistocene times. Since it existed at Casino, viz., during a period when Corsica and Sardinia, for all we know, were connected with one or more parts of Southern Europe, there is every likelihood that during that period of the maximum of regression of the Mediterranean, it likewise flourished in Corsica and Sardinia.

[1] E. Rivière, "Paléoethnologie." "De l'Antiquité de l'Homme dans les Alpes-Maritimes," pl. xvii (Faune des grottes de Menton), fig. 10, Paris (1878)—1887.

[2] Marcellin Boule, "Chronologie de la Grotte du Prince près de Menton": C. R. Paris, vol. cxxxviii, No. 2, pp. 104–106 (1904).

[3] Op. cit., p. 886.

II. *Rhagamys orthodon (Hensel), Murine Rodent from the Pleistocene of Sardinia, Corsica, and Tavolara.*

Rhagamys orthodon (Hensel).

Mus orthodon, Hensel, Zeitschr. deutsch. geol. Ges., vol. viii, pp. 281–289, pl. xiii, figs. 6–10 (1856); Forsyth Major, Atti Soc. Tosc. Sc. Nat., Proc. Verb., vol. iv, pp. 139–145 (1884); Trouessart, Cat. Mammalium, p. 477 (1898–99); Barrett-Hamilton, Proc. Zool. Soc. London, 1900, pp. 421, 422.

In an appendix to his valuable paper "On geographical and individual variation in *Mus sylvaticus* and its Allies," Major Barrett-Hamilton has a note on *Mus orthodon*, which opens with the sentence here reported: "In dealing with *Mus sylvaticus*, I must allude also to *Mus orthodon, which is believed to be very closely allied to it*" (italics mine), "and the skulls and teeth of which in the British Museum collection I have examined."[1] From his synonymy, where we read "(aff. *Muri sylvatico*, fide C. I. Forsyth Major, P.-verb. Soc. Tosc., 1888, p. 129)," it results that I am supposed to be the believer in the very close relation of the fossil with *Mus sylvaticus*. The writer assumes the easy task to show from my own specimens that this very close relation does not exist. The "aff. *Muri sylvatico* . . ." is taken from Trouessart's Catalogue. Neither of my two friends has taken the trouble to understand my detailed description (in Italian) of the fossil in question.

In the original description of *Mus orthodon*, Hensel had arrived at the conclusion that his group of the *Ratten* (*Mus decumanus, M. rattus, M. musculus*) is in some respects intermediate between the fossil and his group of the *Mäuse* (*Mus sylvaticus, M. agrarius, M. minutus*).[2] With more material at my disposal, I was able to show that some of the supposed differences of *Mus orthodon* from the group *Mäuse* did not exist, so that, on a comparison of the fossil with the two groups of European species of *Mus*, it is with the group comprising *Mus sylvaticus*, *M. agrarius*, and *M. minutus* that *M. orthodon* has the greater affinities. It agrees with this group in the following points:—

(1) Presence of a postero-internal cusp (*c″* of Hensel's diagram) in the upper molars.[3]

(2) In m_1 having a greater number of cusps than in the group *Ratten*, in which latter the odd anterior cusp is always missing.[4]

(3) In the pattern of the worn teeth, and

(4) In the number and position of their roots the fossil is likewise more related to the group *Mäuse*.[5]

The peculiar characters of the fossil are clearly proved:—

(1) From my lengthened description of the pattern of the molars.

(2) From their hypselodonty.[6]

[1] Op. cit., p. 421.
[2] Op. cit., p. 289.
[3] Op. cit., p. 44.
[4] Ibid.
[5] Op. cit., pp. 44, 45.
[6] Op. cit., p. 145.

(3) From the peculiar thickness of the enamel layer.[1]

(4) From the more vertical position of the molar tubercles, whence the specific name given by Hensel.[2]

I am, and have always been, so much impressed with the importance to be attached to these peculiar characters of the fossil species, that I deem it necessary to raise it to generic rank.

III. *The Vole from the Pleistocene of Sardinia, Corsica, and Tavolara.*

ARVICOLA (TYRRHENICOLA) HENSELI, Maj.

"Campagnol de Cette, de Corse et de Sardaigne," p.p. Cuvier, Oss. foss., vol. iv, pp. 202, 205, 225, pl. xiv, fig. 7; pl. xv, fig. 29; vol. v, pt. 1, p. 54 (1823).

Hypudæus brecciensis, p.p. Giebel, Fauna der Vorwelt, vol. i, p. 88 (1847).

Arvicola ambiguus, Hensel, Zeitschr. deutsch. geol. Ges., vol. vii, p. 469, pl. xxv, figs. 3, 8, 9 (1855).

Arvicola Henseli, Forsyth Major, Atti Soc. Tosc. Sc. Nat., Proc. Verb., vol. iii, pp. 126, 127 (1882); id., Kosmos, vol. vii, p. 6 (1883); Lydekker, Cat. Foss. Mamm. Brit. Mus., vol. v, p. 322 (1887); Forsyth Major, in De Stefani, "Sul Fostato di Calce della Sardegna," Atti R. Accad. Georgofili, vol. xiv, p. 11 (of author's copy) (1891).

"*Arvicola* groupe d'*amphibius*," Depéret, Ann. Soc. Linn. Lyon, vol. xliv, p. 122 (1897).

Cuvier was of opinion that the voles occurring in the breccias of Cette, Corsica, and Sardinia are all of one species; hence the specific name *Arvicola brecciensis* given to them by Giebel. Hensel proposed for the vole from Bonaria (Sardinia) the name *A. ambiguus*, which is preoccupied by Pomel's *A. ambiguus* (= *Dicrostonyx torquatus*). From a comparison of the figure of the Cette vole in the "Ossements fossiles" (pl. xiv, fig. 25) with my specimens from Toga (Corsica) and Sardinian localities, I inferred the distinctness of the continental form from that of the islands. The former being the first described (by Cuvier), the name *brecciensis* remains for the vole from Cette. Having since had, through Professor Boule's courtesy, the opportunity of examining the original of Cuvier's figure of the teeth from Cette, I was able to confirm the distinctness of the continental from the insular species. The former appears to be identical with some jaws which I have worked out of the Gibraltar breccia, and belongs to the subgenus *Microtus*.

The lower anterior molar (m_1) of the insular fossil vole has not more than three closed triangles,[3] a character which at once excludes the genus *Microtus*, in the restricted sense in which I have recently used this generic term, and places it within the genus *Arvicola*.

The complication of the anterior loop in the m_1 of the fossil, and the confluence of the two anterior triangles of m_2, both of which characters are features of the subgenus *Pitymys*, show that the fossil is more closely allied to *Pitymys* than to the subgenus *Arvicola*

[1] Ibid.

[2] Ibid.

[3] I have found it convenient, in describing the molar teeth of voles, to adopt some terms used by American zoologists, for which see Gerrit S. Miller, jun., "Genera and Subgenera of Voles and Lemmings," North American Fauna, No. 12, Washington, 1896.

(*A. terrestris*, *A. amphibius*, etc.). There is a further agreement of *A. Henseli* with several members of the subgenus *Pitymys*, as at present understood, in some cranial characters. The skull is arched longitudinally, with backward shelving of the occipital; it is throughout rather high, but especially so the subcylindrical

Arvicola (*Tyrrhenicola*) *Henseli*, Maj.
From the ossiferous breccia of S. Giovanneddu n. Iglesias (S.W. Sardinia).
Upper view of the left lower molars (enlarged, × 8).
p. posterior transverse loop; *c.t.* closed triangles; *a.* anterior loop.

brain-case. The group of recent species of *Pitymys*, which agree with the fossil in these characters, are represented by *Arvicola incertus*, Gerbe nec Selys (South-eastern France), *A. ibericus*, Gerbe (Spain), *A. lusitanicus*, Gerbe (Portugal), *A. nebrodensis*, Mina-Palumbo (Sicily), a new species from the province of Lecce (South-eastern Italy), *A. Thomasi*, Barr.-Ham. (Montenegro), and a new species (*A. Savii*, Winge nec Selys) from Greece.

A. Henseli has, however, several cranial and dental characters of its own which have induced me to place it in a separate subgenus (*Tyrrhenicola*). The nasals slope away anteriorly, more than in any other known species; they are also much longer. The whole of the anterior facial portion of the skull is remarkably elongate, and comparatively narrow; accordingly the foramina incisiva, which are provided with sharp margins, are remarkable for their length. The superciliary ridges unite in the middle line to form a sharp longitudinal crest. In the posterior basal portion of the skull the bones are crowded together, the mesopterygoid fossa is short and rather narrow, the posterior palatal fossæ very deep. The tympanal bullæ are comparatively small. Some of the preceding characters had already been pointed out by Cuvier,[1] as well as by Hensel,[2] who both had fragmentary crania from Sardinia at their disposal.

The incisors, as well as the molars, are weak when compared with the size of the skull.

All the molars are rootless throughout life. A peculiar feature of the molars, in which they approach the voles of the Upper Pliocene (*Mimomys*), which, however, are rooted, consists in the dentine spaces being more or less confluent with each other, so that, strictly speaking, there are no absolutely closed triangles. This character has been much exaggerated in the figures of the vole from Sardinia published by Hensel,[3] more especially in the two anterior lower molars. It is a general feature of the molars of all young voles.

[1] Op. cit., p. 205.
[2] Op. cit., pp. 471, 472, 475.
[3] Op. cit., pl. xxv, figs. 3*a*, *b*.

The following *dimensions in millimetres* are taken from specimens collected by myself in the ossiferous breccia of Monte San Giovanni, near Iglesias (South-west Sardinia).

	Cranium (B.M. M. 8156).	Imperf. cranium (B.M. M. 3488).	Mandibular ram (B.M. M. 3488		
			b	*f*	*b*
Basilar length	27	—			
Length of nasalia	10·5	—			
Length of foramina incisiva ...	7·1	7·4			
Length of diastema	10·1	10			
Fronto-palatal height above m_2	—	11·7			
The same, including the tooth ...	11·9	12·2			
Length of upper molar series ...	7·2	6·9			
Length of lower molar series ...	—	—	7·2	6·8	6·5

In five upper jaws (M. 3488*c*, *d*, *e*, *f*, and *g*) the length of the upper molar series is respectively 6·9, 6·8, 6·5, 6·5, 7·1. In nineteen upper jaws remaining in my hands, the length of the upper molar series varies from 6·3 to 7·3. These two extremes are represented by only one specimen each. The remaining seventeen have the following dimensions:—Three, 6·4; three, 6·5; three, 6·6; five, 6·7; one, 6·8; two, 7.

VI.—The occurrence of *Anthracomya Phillipsi* in the Durham Coalfield.

By John T. Stobbs, F.G.S.

THIS important Coal-measure zonal Lamellibranch has already been recorded from the Yorkshire and Nottingham Coalfield (Cadeby and Gedling Colliery respectively), the Lancashire Coalfield (Ardwick, Manchester), the North Staffordshire Coalfield generally, the Forest of Dean and Bristol Coalfields, the South Wales Coalfield; and in all these widely separated districts it is found at the top of that portion of the Coal-measures characterised by the presence of the most valuable seams of coal.

In North Staffordshire *Anthracomya Phillipsi*, at one part of its zone, is associated with *Carbonicola vinti*, and this horizon has been widely traced.[1] Now, *Carbonicola vinti* was first recorded by J. W. Kirkby from the Coal-measures near Hylton in the county of Durham, under the name of *Ancylus vinti*,[2] and being familiar with the occurrence of these two forms in North Staffordshire the writer felt that the Hylton section should be specially searched for *Anthracomya Phillipsi*. Accordingly, on 25th August last an opportunity was afforded him of visiting Kirkby's section, which he experienced no difficulty in recognising from Kirkby's description. The locality now threatens to attract a denser population, and it may be wise to give the position of the exposure with greater precision. It occurs on the left bank of the River Wear (lat. 54° 55′ 5″ N.; long. 1° 25′ 50″ W.), and is marked on the Geological Survey maps by a fault. It is true that the Coal-measures abut against the Permian yellow sands as sketched by Kirkby in the paper referred to, but

[1] Wheelton Hind: Quart. Journ. Geol. Soc., vol. lv, pp. 367–8.

[2] James W. Kirkby: Trans. Tyneside Nat. Field Club, vol. vi, pp. 220–225.

there was not enough evidence at the section to determine whether this juxtaposition of Permians and Coal-measures represents a post-Permian fault or simply a steep bank-side of eroded Coal-measures against which the Permian Yellow Sands were deposited. The colliery workings, however, should definitely settle the matter.

The following is the section of Coal-measures at this point :—

	ft.	in.
Grey laminated shale		
Dark shales with nodular bands of ironstone (*A. Phillipsi*, *C. vinti*, etc.)	3	0
Grey gritty shale	1	6
Grit	3	0
Laminated arenaceous shale	2	0 +

Kirkby gave the position of these beds as not much more than fifty or sixty feet from the top of the Coal-measures, but this datum-line is a very uncertain one, owing to the pre-Permian denudation of the Coal-measures in the great Northern Coalfield. The most satisfactory method is to fix the horizon with respect to one of the well-known coal-seams of the Durham Coalfield, and the writer is indebted to Mr. Mark Ford, of Washington Collieries, who is familiar with the ground in question, for the information that the Hutton seam lies almost flat at a depth of about 1,700 feet in this locality. The measures are at the surface, almost at the deepest part of the coal-basin.

From the ironstone bands the writer collected :—

Anthracomya Phillipsi (Will.). Abundant.
**Carbonicola vinti* (Kirkby). Abundant.
**Beyrichia arcuata*, Salt. Not common.
Carbonia sp. Not common.
Spirorbis sp. Not common.
**Neuropteris gigantea*, Sternb. Not rare.

Those marked with an asterisk were recorded by Kirkby, together with *Diplodus gibbosus*, Ag., and other fish-remains. In addition he mentions *Anthracomya acuta*. Dr. Wheelton Hind, however, is unacquainted with this species, and very curiously, after talking the matter over with Mr. John Ward, F.G.S., that gentleman showed the writer a specimen of the ironstone containing *C. vinti* given to him by Kirkby, and on the outside of the nodule, hitherto unrecognised, were numerous individuals of *A. Phillipsi*. There is no doubt, therefore, that Kirkby's *A. acuta* should have been referred to *A. Phillipsi*.

The interest of the discovery lies in the proof of the existence of the *Phillipsi*-zone near the top of the Coal-measures in the Durham Coalfield, and, so far as we may legitimately infer from the character of the immediately-overlying measures in other coalfields, that in all probability the pre-Permian denudation did not remove much of the Coal-measures that are of special commercial value, but, on the other hand, it has rendered the excellent coal-seams of that district much more accessible. The writer desires to thank Dr. Wheelton Hind for verifying the naming of the Lamellibranchs mentioned in this note; this discovery is the natural outcome and verification of principles laid down by him.

VII.—Recent Marine Clays at Kuchavelli, Ceylon.

By Ananda K. Coomáraswámy, B.Sc., F.L.S., F.G.S., Director of the Mineralogical Survey of Ceylon.

Kuchavelli is twenty-two miles north of Trincomalee on the east coast of Ceylon. Two miles south of Kuchavelli is the mouth of the Salape aru. On the right bank of this river, near the mouth, raised beach, consisting of shelly sandstone, is exposed. The sandstone is often full of marine shells, and there are also thick growths of oysters attached to upstanding masses of rock. The bed is from 6 inches to 2 feet in thickness, and is exposed about 1 foot above high-water mark, and stretches down the sloping bank between tide-marks. This is the ordinary raised beach of Ceylon, a deposit usually occurring at or below high-water mark, and now being continually eroded at numerous points on the coast of Ceylon where it is exposed (e.g. Bentota). This deposit will not now be further spoken of.

The Salape aru is really the name of the estuary of several rivers; proceeding up the river inland, the Matti aru is reached, a shallow river with alluvial banks eight or ten feet above the water on either side. Extensive sandbanks are found on one side or the other of the river, alternating on the meanders with places where erosion is in progress. These banks are covered with marine shells, the large flat Placunas being most common. There are also found clayey nodules including marine shells, crabs, and it is said sometimes tortoises and fishes. The crabs are collected for use as medicine, being powdered and mixed with milk or water as a specific for diabetes. The crabs fetch from 25 cents to a rupee each, according to size.

The shell-covered sandbanks continue for some distance. The crab bed and source of the marine shells was detected *in sitú* about a mile and a half from the mouth of the river and not far from a hill called Nachchiyar Malai. The bed is exposed in the river bank, and the section is roughly—

	ft.	ins.
1. Soil and alluvium	9	0
2. Crab bed=clay full of marine shells, nodules, etc.; in parts sandy	2	6
3. ? More sandy beds underlying the clay.		

Nearly all the shells common on the sandbanks, as well as a crab nodule, were found *in sitú*. The top of the fossiliferous clay is probably about one foot or less above sea-level, and the fossils occur chiefly in the lower part and have to be dug out from below water-level. Beside the shells, etc., small pieces of wood are common in the clay, and crystals of selenite also occur. It is simply crowded with the flat Placunas (?).

In the Colombo Museum are a number of fossils from Palantiar, the exact situation of which I am uncertain. The crabs are also said to be found at Mullaitivu, on the coast north of Kuchavelli.

The bed can hardly be described as ordinary raised beach, but occurs at the same level as the usual sandy raised beach, which it appears to replace rather than to over- or underlie.

*** We subjoin a note on Mr. Coomáraswámy's fossils, which have been most kindly examined by Mr. R. Bullen Newton, F.G.S.—Edit. Geol. Mag.

VIII.—Note on some Post-Tertiary Mollusca from Ceylon.

By R. Bullen Newton, F.G.S., of the British Museum (Natural History).

Some marine shells, associated with crab-remains,[1] Balani, and small thread-like annelid tubes, from the Post-Pliocene deposits of north-eastern Ceylon, have been entrusted to me for determination by Dr. H. Woodward, F.R.S. They were collected by Mr. A. K. Coomáraswámy, B.Sc., Director of the Mineralogical Survey of Ceylon, and his description of the deposits containing the fossils forms the preface of this communication. Lithologically it is observable that there are two sets of specimens—those that occur in hard, water-worn nodules of clay, and others that were obtained from soft, dark, clayey beds found *in situ*. The fossils found in the clayey material may perhaps be rather older than those found in the nodules, but as two of the shells are common to each, viz. *Placuna placenta* and *Potamides fluviatilis*, it is certain that no great distinction in age is to be recognised.

An examination of the species represented in the collection goes to prove that they belong to the existing fauna of the Indian Ocean, being similar to the life which is found in the creeks and back-waters of that sea, and consequently bearing a littoral or an estuarine facies.

It is interesting to know of the presence of corresponding Post-Tertiary deposits crowded with shells forming the coastal areas of the Madras Presidency of India, particularly at Pondicherry, Cuddalore, Tangore, etc., for the history of which we are mainly indebted to the late Mr. H. F. Blanford (Mem. Geol. Surv. India, 1862, vol. iv. pt. 1, pp. 192, 193). So numerous are the mollusca of these beds that they are utilised by the natives for the manufacture of lime. From lists given by Mr. Blanford it is ascertained that these mainland deposits contain molluscan species identical with those found in Ceylon by Mr. Coomáraswámy, a fact which not only suggests a similarity of age, but also proves that the separation of Ceylon as an island can be referred to a very modern epoch of geological history.

The following is a list of shells found in the Post-Pliocene beds

[1] The small, nearly perfect crab has been determined by Dr. H. Woodward as *Macrophthalmus Latreillei* (Desmarest), the 'Medicine Crab' of the Chinese pharmacopœia (see Daniel Hanbury, "Notes on Chinese Materia Medica," Pharmaceutical Journal and Trans., July and August, 1860, and February, 1862, published separately by the author, February, 1862, Plough Court, Lombard Street, E.C.); and the chelate pincer as belonging to *Scylla serrata*, De Haan, the great Indian swimming crab. *M. Latreillei* is also found in the Post-Tertiary clays of southern China (Island of Hainan), and *S. serrata* has been reported from similar beds in the Philippine Islands.

of Ceylon and their occurrence in the Madras deposits. These determinations have been made with the kind assistance of Mr. Edgar A. Smith, I.S.O. It is satisfactory to note also that the specimens have been presented to the Geological Department of the British Museum by the collector, A. K. Coomáraswámy, Esq., B.Sc., etc.

	Ceylon.	Madras.
GASTROPODA.		
Telescopium telescopium (Linnæus)	X	X
Potamides fluviatilis, Potiez & Michaud	X	X
Purpura carinifera, Lamarck	X	X
Nassa ornata, Kiener	X	
Melongena pugilina (Born)	X	X
Natica sp.	X	
LAMELLIBRANCHIA.		
Scapharca rhombea (Born)	X	X
Arca sp.	X	
Placuna placenta (Linnæus)	X	X
Tapes undulata (Born)	X	
Tapes textrix (Chemnitz)	X	
Diplodonta cf. *oblonga*, Hanley	X	
Tellina sp.	X	
Dosinia salebrosa, Roemer	X	
Chione allied to *imbricata* (Sowerby)	X	X

REVIEWS.

I.—THE GEOLOGY OF CYPRUS.[1] By C. V. BELLAMY, M.I.C.E., F.G.S., late Director of Public Works in Cyprus, and A. J. JUKES-BROWNE, B.A., F.G.S., late of the Geological Survey of Great Britain.

IN the beginning of the present year, 1905, a geological map and letterpress key of the Island of Cyprus, compiled by Mr. C. V. Bellamy, late Director of Public Works, was published by Edward Stanford.[2] This was almost entirely the result of work done in the field, and has now been followed by a more detailed and comprehensive treatise on the same subject with Mr. A. J. Jukes-Browne as joint author. It could have been wished that both had appeared simultaneously to form one harmonious work, the several parts forming the complement of the other, in which case the few discrepancies and alterations which now exist would have been obviated. One of the most important additions in the newer work, and included in the sketch-map which forms its frontispiece, is the recording of an outcrop of a bed of later Pliocene age situated west

[1] Plymouth, W. Brendon & Son, Ltd., 1905, and read before the Geological Society, 4th January, 1905.

[2] See notice in GEOL. MAG., March, 1905, pp. 117–126.

of Myrtou in the Kerynia District. It is of considerable extent, and has yielded specimens of *Ostrea cochlear*, obtained by Mr. Nicolls, besides large numbers of Foraminifera, of which a list of 186 species identified by Mr. F. W. Millett is given in Appendix iii.

Although several memoirs, including an interesting account of the Larnaka Salt Lake by Mr. Bellamy, have appeared since Professor Gaudry's important work,[1] the two publications mentioned above form the first comprehensive treatise on the geology of the whole island published since the completion of the Trigonometrical Survey in 1882, and the authors are to be congratulated on the manner in which this has been performed. Mr. Jukes-Browne has not visited Cyprus, but, besides being jointly responsible for most of the opinions expressed, he has contributed "all the descriptions of the lithological composition and microscopical structure of rocks, as well as comments on the fossils and inferences as to the relative age of the several rock groups." On the other hand, Mr. Bellamy has had five years experience of the island, almost every corner of which he appears to have visited, and it must be mentioned that it was entirely due to his own individual enterprise that these geological labours were undertaken and brought to so successful an issue.

Roughly speaking, Cyprus may be said to be made up of a central mass of igneous mountains, the Northern or Kerynia Range of limestone hills bordered on either side by the 'Hummocks' (Kythræan Series), the generally hilly, white chalky country (Idalian Series), and the later deposits of which the Messaoria and coastline are chiefly composed. The descriptions of these various formations and their subdivisions and the recording of a number of outliers in different parts of the island give evidence throughout of the immense care and continual close observation which have been brought to bear on the subject. At the same time the work is by no means over-elaborated, nor does it contain unnecessary repetition of matters already fully entered into in more specialised memoirs; rather it is a comprehensive and concise summary of our knowledge up to date of the subject, which has been verified and corrected at first hand and further largely added to.

In connection with the alluvial plains some interesting and suggestive facts are given with regard to the raising of the general level of the Messaoria by means of the silt brought down by the streams and rivers from the mountains by which it is bordered in two directions. After the mention of several phenomena which help to prove this, we read (p. 49) that "This would yield as a mean rate of elevation of the surrounding country of, say, one foot in a hundred years." It is seemingly owing to this, in conjunction with the formation of sand-bars, that the eastern portion of the Messaoria has become the fertile corn land that it now is instead of remaining an inland extension of the Bay of Famagusta. That there have been analogous, though less extensive, alterations in other parts of the coastline during comparatively recent times, is

[1] Published in 1862.

suggested, we are told (p. 51), by a map published in 1579, in which several examples of these changes are indicated.

From earliest historical times Cyprus has known a continual change of ruler, owner, and occupier, and during its geological past it has been no less the scene of many and varied changes. In chapter viii we are given an interesting summary of the physical history of the island with maps showing the different aspects of Cyprus during two previous epochs. Its former connection with the mainland *viâ* the Karpas and the present Gulf of Iskanderun seems to be a fairly established fact.

One of the chief drawbacks to commercial enterprise on any large scale is the possible insecurity felt on account of Cyprus being in point of fact still a portion of the Ottoman Empire. However, setting this aside, we find as a result of scientific investigation that there is not the amount of inducement that might have been expected from the island's former reputation for great mineral wealth. The copper, which was worked by the Phœnicians and probably also by the Romans, does not appear to have been rediscovered in any great amount. A few other minerals occur, but apparently only in small quantities. In the chapter (ix, pp. 57–66) devoted to the economics of the island is refuted an error, formerly supported by no less an authority than M. Gaudry, to the effect that Cyprus was devoid of marble. In fact, we read on p. 57 that "It is now placed beyond all doubt that the beds of marble are of great extent, and the varieties numerous and frequently beautiful." Further, a number of specimens were sent to a sculptor and expert in marble, whose verdict proclaimed them to be of excellent quality, one being "equal to the best Parian marble." We believe that this discovery is entirely due to Mr. Bellamy. These marbles are all found in the Trypanian Rocks, which are almost entirely confined to the Kerynia Range, which also produces lime of a very fine description. From the Idalian Series alabaster is obtained and also gypsum, which is exported in considerable quantity. Building and paving-stone of various qualities occur in many parts of the island, the best being supplied by the shelly limestones of the Pliocene and Pleistocene beds. It was perhaps considered to be beyond the scope of this work, but at any rate we are not told whether these marbles, or any other of the mineral products, are likely to become of any very great commercial importance to the island in the future.

The transliteration of Greek into English is frequently a stumbling-block, and in this case it could be wished that there were a little more uniformity in the spelling of place-names, which frequently does not agree in the map and its key with that in the work under discussion, and does not even always correspond in the one publication. This is apt to give a suggestion of carelessness to be deprecated in a scientific work. However, this is a small matter and can hardly detract from the usefulness of this valuable and much needed work on the geology of Cyprus. D. M. A. B.

II. — Extinct Animals. By E. Ray Lankester, M.A., LL.D., F.R.S., Director of the Natural History Department, British Museum. 8vo; pp. xxiv and 332, with 218 illustrations. (London: Archibald Constable & Co., Ltd. Price 7*s.* 6*d.* net.)

IT is a fortunate circumstance that the lectures delivered at the Royal Institution orally, with lantern illustrations, last Christmas, by Professor Ray Lankester, should, before another Christmas has yet arrived, be printed as a book, not only admirably suited to boys and girls, but for men and women also, with an abundant amount of illustrations in the text calculated to make it most attractive to the general reader.

Everyone will recollect the droll creatures so cleverly invented by Tenniel for "Alice in Wonderland," and one cannot help feeling that with many of Professor Lankester's monsters the children of to-day will be equally delighted. What, for instance, could be more quaint than the probable appearance of *Iguanodon* (p. 198), or the dear little *Arsinöitherium* (p. 153). Nor is the long-jawed Mastodon (*Tetrabelodon*) without a certain comic Christmas aspect (p. 119). The artist has, by accident, put the prehensile tip of the animal's proboscis *below*, instead of above, the nasal aperture, but this is the only serious slip we have noticed, and for a picture-book of extinct animals it is the best of its kind we have ever seen. The book, however, is much more than a book of pictures; it is full of information presented in an agreeable form for the non-scientific public, and is very much up to date. The only new animal which came over from America too late to find a place in its pages is Mr. Carnegie's *Diplodocus*, which one must go to the British Museum to see.

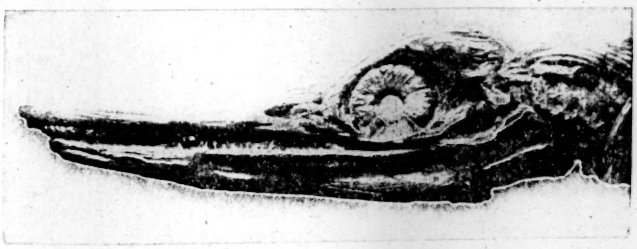


Fig. 1.—Head of an *Ichthyosaurus*, from the Liassic rocks of Lyme Regis, in the Natural History Museum. The head is 3 feet 6 inches long.

Professor Lankester, among many other attractions, introduces his audience to a fascinating skull of an extinct monster which he remembered to have seen in his own youthful days in the Natural History Museum, "then in a remote part of London called Bloomsbury, but now in Cromwell Road, Kensington. It is the head of an *Ichthyosaurus* dug out of the rock in the South of England, at Lyme Regis, many years ago. The eye is peculiarly well-preserved.

The circle of bony plates, similar to those found in the eyes of birds, gives an expression of interest which few fossils can boast of" (p. 6).

The author tells of the 'Mammoth' whose skeleton was found in frozen soil in Siberia, by Adams, a century ago, now in the St. Petersburg Museum, upon whose bones, when first discovered, the flesh and skin were still preserved, but much of the soft parts had been devoured by the wolves, foxes, and other animals, who feasted on *preserved meat* for weeks, before the skeleton (with what little remained of the soft parts) was transported from the banks of the Lena to St. Petersburg.

But the latest discovery of a Siberian Mammoth was made in 1901, in the province of Jakutsk, where an entire skeleton of *Elephas primigenius*, clothed in flesh, hair, and hide, was unearthed on the banks of the Beresowka, a tributary of the Kolyma, and was successfully carried to St. Petersburg, the skeleton being set up in the Academy Museum, and also the skin, which has been prepared by a taxidermist, softened and stuffed, like that of a modern animal, in the attitude of death, surrounded by the morass in which it made its last struggle (see GEOL. MAG., 1903, pp. 361–363, Pl. XVIII).

A considerable space is devoted to the recent discoveries made by Professor Amalitzky, of Warsaw, of a whole series of skeletons of Theromorph reptiles (closely similar to those from the rocks of Cape Colony) from the banks of the Northern Dwina, near Archangel in North Russia. He has not yet finished his excavations nor published the results, but has allowed Professor Lankester to refer to them and to show the photographs. The remains were found in immense nodular masses harder than the soft Permian strata forming the cliffs in which they lie imbedded. These nodules had been long used for mending the roads, and when broken open displayed the bones of reptiles. Professor Amalitzky had them dug out and conveyed to the University of Warsaw, where they are being gradually worked out and mounted, the Imperial Academy of St. Petersburg allowing him a thousand pounds a year towards the expenses. There were many skeletons of *Pariasaurus*, like that obtained by Professor Seeley from the Karroo Beds in South Africa, and several of a huge carnivorous reptile (*Inostransevia*) allied to *Lycosaurus*, also found in Cape Colony.

Professor Lankester points out the interesting fact of the presence, even in these early Triassic times, of the two types, the carnivorous and herbivorous dwelling together, the bloodsucker and its victim, just as in Jurassic times the two types of Dinosauria occur, and at the present day the Carnivora and Herbivora exist side by side in Africa and India and indeed over a far wider extent of the earth.

The lecturer gives an interesting account of the Old Silurian and Devonian fishes about which he formerly contributed a monograph to the Palæontographical Society. He also discourses upon the Pearly Nautilus, the Cuttle-fish, and their ancient allies the Belemnites and Ammonites, many figures of which are given. The Trilobites, and next the giant Merostomata, the *Pterygotus*, *Eurypterus*, *Stylonurus*, *Slimonia*, and their relatives the King-crabs

and Scorpions, occupy the field, and we see how forms adapted for an aquatic existence may have their external leaf-like breathing organs transformed into internal tracheæ suitable for air-breathing terrestrial dwellers.

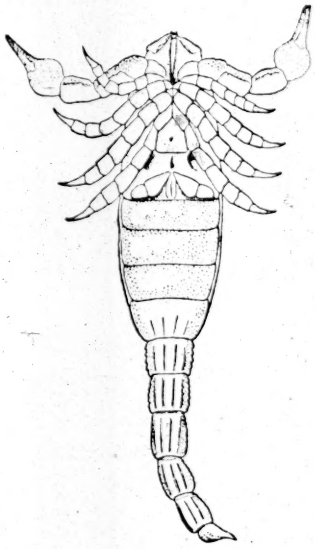


Fig. 2.

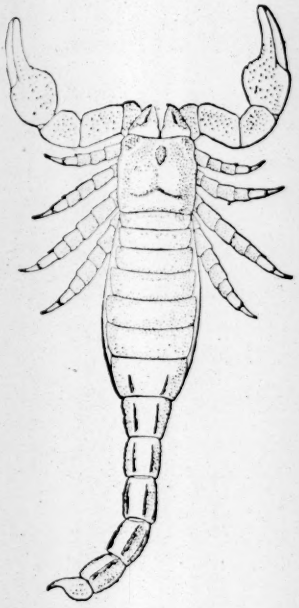


Fig. 3.

Fig. 2.—Restored figure of the Scotch Silurian Scorpion (*Palæophonus Hunteri*), seen from below, to show the bases of the legs.

Fig. 3.—Restored figure of the Silurian Scorpion from Gothland (*Palæophonus nuncius*), seen from above.

One is astonished to find amid a changing world, in which whole races of animals have appeared and disappeared over and over again, that such simple creatures as king-crabs and scorpions date back their ancestors to the Silurian period in Europe and America, and still form a part of the living population of the world, the scorpions dwelling in dry desert countries widely distributed over the old and new world, the king-crabs along the Atlantic American seaboard, and also in the Indian, China, and Japan seas.

As to the size of animals, the lecturer reminds us that the ancestors of the elephant, the horse, and other living types were quite small forms; and that the hugest of huge reptiles, the extinct *Diplodocus*, 80 feet in length, is exceeded in bulk by the Right Whale, belonging to the highest existing class, the Mammalia.

We predict for this book many readers, and, as a result, many more visitors to the Natural History Museum, over which the author, Professor Lankester, presides.

III.—Egyptian Geological Survey.

The Topography and Geology of the Fayûm Province of Egypt. By H. J. L. Beadnell, F.G.S., F.R.G.S. 4to; pp. 102, plates i–xvi from photographs, 2 maps, 6 sections, and 10 figures in the text. (Cairo: National Printing Department, 1905.)

THE Province of the Fayûm is deeply interesting alike to the archæologist and the geologist. It occupies a large circular depression in the Lybian Desert, situated some 50 miles south-west of Cairo, and immediately west of that part of the Nile Valley lying between Kafr el Ayat and Feshn. The depression, which, roughly speaking, has an area of about 12,000 square kilometres, comprises within it three distinct parts—(1) cultivated land, (2) lake, and (3) desert.

(1) The cultivated land has an area of about 1,800 square kilometres, and, with the exception of the lake and part of the Wadi Rayan, it occupies the lowest part of the depression. This region is everywhere covered with alluvial soil, identical for the most part with the river alluvium of the Nile Valley, and is bounded by the desert on the south and east sides, and by the lake, Birket el Qurûn, on the north-west. It forms a more or less level plain, from which the ground slopes gently away, on the north side towards the lake. The Fayûm is directly connected with the Nile Valley by a narrow strip of low ground, a natural passage through the desert separating the Nile Valley and the Fayûm depression. Through this gap runs the natural canal known as the Bahr Yusef, which is the sole source of water in the Fayûm, irrigating the entire district. Once within the Fayûm the Bahr Yusef gives off numerous subsidiary canals which traverse the country in all directions, constantly splitting up into smaller branches until the water supply is divided throughout the whole area, finally draining into the Birket el Qurûn lake, the surface of which is now 44 metres below the level of the Mediterranean. There are two deep dry depressions to the south-west known as the Wadi Rayan and the Wadi Muêla; these have been examined by Mr. Beadnell with the idea of possibly utilising them in connection with a Nile reservoir.

(2) The present lake, which is from 80 to 90 square miles in extent, represents the existing remnant of the once celebrated Lake Moeris, which, in the reign of Amenemhat I and his successors of the Twelfth Dynasty, covered a large part of the floor of the Fayûm depression, and was converted by them into an artificially controlled sheet of water and used as a regulator of excessively high and low Nile floods in connection with the irrigation of the Nile Valley. The lake is now greatly reduced in size; in prehistoric times it must have been of immense extent—Mr. Beadnell thinks probably ten times the size of the modern Birket el Qurûn—for lacustrine deposits showing approximately the actual limits of the ancient Fayûm lake can be traced over wide areas of now barren desert.

(3) The desert region to the north of the lake is composed of beds of Middle and Upper Eocene age, forming a series of escarpments. It was here, within the past four years, that the most surprising results have been obtained by the palæontologist, almost surpassing in interest the truly remarkable discoveries which had rewarded the earlier labours of Marsh, Osborne, Scott, and others in North America. When Schweinfurth crossed the region in 1879 he found fossil bones, which were determined by Dames to be the remains of Cetacea of the genus *Zeuglodon*. These appear to have been the earliest vertebrates obtained from the Fayûm. In April, 1901, some of the localities, previously noticed by Mr. Beadnell in 1898 to be bone-bearing, were revisited by him, in company with Dr. C. W. Andrews, of the British Museum, then spending the winter in Egypt,[1] when additional evidence of fossil vertebrates was met with. A new locality was also discovered further north (where the outcrop of the bone-beds was crossed), and a considerable number of mammalian and reptilian bones was observed exposed at the surface, including remains of Sirenians, *Zeuglodon*, etc., the most important land mammalia being *Palæomastodon Beadnelli*, *Mœritherium Lyonsi*, *Barytherium grave*,[2] etc. Later on the remarkable new ungulate *Arsinoïtherium Zitteli*, Beadn., was discovered by Mr. Beadnell (see Geol. Mag., 1903, pp. 529–532, Pls. XXIII and XXIV) with many others. Important and wonderful as these discoveries are, their value is greatly enhanced by the extraordinary completeness of the stratigraphical record exhibited in the very clearly exposed and regular series of deposits laid bare on the flanking cliffs and escarpments on the northern side of the Fayûm, of which the author gives a large number of sections with details of each separate bed. Thus we commence with a magnificent exposure of Middle Eocene (Parisian) strata, having a thickness of 1,300 feet, yielding Nummulites, Mollusca, fish-remains, and species of *Zeuglodon* with remarkably primitive dentition, and accompanying these, remains of a vertebrate land-fauna. Then follows the Upper Eocene (Bartonian), 830 feet in thickness, which has yielded abundance of vertebrate remains, the commonest being *Palæomastodon*, *Arsinoïtherium*, *Mœritherium*, and Chelonians.[3]

Still, in ascending order one meets with Oligocene (Tongrian) beds with a thickness of 100 feet of fluvio-marine beds, containing also silicified tree trunks in great abundance, with a sheet of hard basalt at the top. The youngest beds are gravel terraces and lacustrine clays, deposited by the ever-diminishing waters of the

[1] Dr. Andrews subsequently paid three other visits to Egypt, and the results of his collections in the Fayûm, and of duplicate specimens contributed by the Survey, may now be seen in the fine series of objects exhibited in the cases of the Geological Department (Natural History), Cromwell Road. We are glad to learn that a Catalogue by Dr. Andrews, published under the joint auspices of the Trustees of the British Museum and the Survey Department of Egypt, will shortly appear, with figures and descriptions of the fossil vertebrates of this remarkable region.

[2] See Geol. Mag., 1901, pp. 400–409 and 436–444; 1902, pp. 291–295 and 433–439; and also on the Geology, 1901, op. cit., pp. 540–546.

[3] See paper by Dr. C. W. Andrews, Geol. Mag., 1903, pp. 337–343.

lake (Birket el Qurûn), also sands blown from the desert, and alluvial deposits.

"In a thickness of 700 metres (2,266 feet) these beds include every kind of sedimentary deposit—limestones, marls, clays, sandstones, sands, and gravels, forming an ever-changing succession of rocks, varying considerably in hardness and capacity for withstanding the agents of denudation. It is not too much to say that the coming into existence of the Fayûm, with its plains, low-lying depressions, precipitous cliffs and escarpments, was largely dependent on the nature of this variable series of deposits" (p. 15), out of which this hollow has been carved.

In reference to the origin of the Fayûm, Dr. Blanckenhorn describes it as a triangular depression *bounded on all sides by faults*, the position of which he shows on a map accompanying his paper.[1] "As these fault-lines lie for the most part within the area covered by the alluvial deposits and the waters of the lake, it is not easy, for want of exposures, to disprove their existence. But the fault along the east side follows the junction-line between the desert and the cultivated lands. Along this line everywhere the marls and limestones of the Ravine-beds pass regularly from the desert under the cultivated lands without any sort of break or dislocation, whilst an examination of the desert ridge to the east disproves the existence of any faulting on the desert side." "A few kilometres to the west the same beds appear in the ravine of El Bats, proving their continuity *under the cultivated alluvium* in this direction." The author deals with all the other faults propounded by Dr. Blanckenhorn, and concludes, after careful examination, that no evidence in favour of the existence of such faults was met with, and that everywhere the strata occupy their normal undisturbed level stratigraphical position (pp. 30 and 31).

"No evidence has as yet been met with," says Mr. Beadnell, "which would suggest that earth-movements have played any important part in the formation of the Fayûm depression. In fact, an examination of the desert margin conclusively proves that the depression has been cut out through the action of ordinary subærial denuding agents" (p. 29).

The author pictures the condition of the Fayûm in Eocene times, and suggests that a great river flowed in a north-easterly direction along the line of the Baharia Oasis from a well-wooded continental area hundreds of miles to the south, carrying along with it in flood-time vast masses of matted rafts of forest trees, and bearing seawards the carcases of those curious Eocene animals the remains of which are so abundant in the Fayûm of to-day.

The memoir is distinctly in advance of its predecessors both in the printing and in the quality of its illustrations, which have been very carefully executed; the frontispiece, representing the Bahr Yusef at Lahun, before entering the Fayûm, is an excellent picture, and the plate (x) of the El Qatrani range, showing the magnificent basalt-capped cliffs, is also very good. The plate of the isolated sand-dune

[1] Blanckenhorn, "Geologie Aegyptens," Berlin, 1901, pt. iv, pp. 339–344.

near Gar el Gehannem (pl. xv) illustrates the difficulties which often impede the traveller in crossing such desert tracks, some of these dunes being practically impassable by caravans for miles.

Of the curious blocks of sandstone, pierced by numerous borings, we shall have something more to say on another occasion. They appear to be the exact replica of specimens brought home from Lake Tanganyika by Mr. J. E. S. Moore.

The maps and sections are most excellent. We congratulate the author and Captain H. G. Lyons, F.G.S., the Director General of the Surveys Department, on this most admirably executed memoir.

REPORTS AND PROCEEDINGS.

British Association for the Advancement of Science. Cape Town, South Africa, August 16th, 1905.

Address to the Geological Section (C) by Professor H. A. Miers, M.A., D.Sc., F.R.S., President of the Section.

(*Concluded from the October Number, p.* 478.)

Supersaturated Solutions.

I DO not myself see how we can do otherwise than apply to the study of rock-magmas all that can be learnt from physical chemists concerning the behaviour of solutions, for though we cannot attain in laboratory experiments the high temperatures and great pressures at which rocks may have crystallised, there is no reason to believe that these introduce more than a difference of degree. The principles of equilibrium between the various crystallising components probably remain the same, whatever may be the temperatures and pressures at which they have solidified.

It must at the same time be confessed that most of the experiments upon which the modern theory of solutions has been built up have been conducted upon dilute solutions, whereas the problems of crystalline growth are concerned, not with dilute nor even with saturated solutions, but only with solutions which are supersaturated. There is some force in the objection of Doelter that the results of such experiments may not be directly applicable to crystallising slags.

For example, as I have already mentioned, doubt has been expressed in the case of silicate magmas, whether the substances in solution are the minerals about to crystallise or only their constituents; whether viscosity and supersaturation may not invert the theoretical order of their appearance; whether we are to take into account possible dissociation of the molecules or not; whether the presence of a common ion in these minerals is a factor which determines their mutual solubility. In fact, very little is known about the actual condition of the materials in a strong solution, although I do not know that there is any evidence available which forbids us to regard a solution about to crystallise as a mixture of liquids one of which is about to pass into the solid state.

But if little is known about the nature of strong and supersaturated

solutions, a good deal may be learnt about their behaviour. Having complained that we need experiments in this field, I may perhaps be pardoned if I allude to some unpublished experiments of my own which relate to the general behaviour of crystallising liquids, and appear to me to explain two difficult problems in petrography. To such experiments the objection of Doelter does not apply.

The Metastable and Labile Conditions.

When a solution of any salt such as alum or sodium nitrate is allowed to crystallise at a uniform temperature the crystals will only grow so long as the solution is supersaturated; a crystal growing in the supersaturated solution will continue to do so until a condition of equilibrium is attained. If the solution be kept at rest and maintained at a constant temperature, the crystal will continue to concentrate the liquid around itself and to withdraw solid material, until by diffusion of the impoverished liquid the whole mass is ultimately reduced to saturation, equilibrium is established, and the crystal ceases to grow; but most saturated solutions are so viscous that a very long time is required before this point is reached. Prolonged and vigorous stirring is required if the supersaturation is to be completely relieved within, say, a day; without stirring, weeks may be required.

Further, it may be possible, as is well known, to keep a supersaturated solution in a sealed tube for years without change; and it is also possible to start crystallisation in such a liquid by dropping into it a crystal of the dissolved substance, or of one isomorphous with it, or sometimes by shaking it.

But it is, perhaps, not generally known that supersaturated solutions are of two sorts.

In 1897 Ostwald published some experiments upon supercooled liquids and supersaturated solutions, which were carried out with the object of showing how extraordinarily minute are the quantities of solid material capable of starting crystallisation in such liquids, but at the same time that they have a limit of size. He called attention to the radical difference which probably exists between the state of a saturated solution which cannot crystallise spontaneously and that of the more strongly supersaturated solution which can do so.

The former is one in which crystallisation can either take place spontaneously or can be induced by stirring or shaking, or a variety of causes: this Ostwald calls the *labile* state. The latter is one in which crystallisation can only take place if a solid crystal of the dissolved substance, or a fragment of one, is brought into contact with the liquid: this he calls the *metastable* state. It is highly probable that no amount of stirring or shaking, or introduction of foreign substances, can make the metastable liquid crystallise.

Until recently no attempt to ascertain the exact limit between the metastable and labile states, or even to establish the existence of such a limit, had been successful, and practically no attention has been paid to the difference between them. Tamman, who measures the velocity of crystallisation by counting the number of the centres

of growth or nuclei which appear in a supersaturated solution, does not recognise any distinction between the two states.

During the present year a number of experiments carried on by Miss F. Isaac and myself upon the strength of solutions from which crystals are growing have shown that it is easy to determine the changing concentration of a cooling solution by an optical method, to show that it passes into the labile state, and to ascertain the temperature at which the transition occurs. We have found, for example, that a solution containing 48 per cent. of $NaNO_3$ is saturated at 26°, is metastable between 26° and 16°, and crystallises spontaneously below that temperature; one containing 52 per cent. of $NaNO_3$ is saturated at 44°, and becomes labile at 35°.

In the metastable state inoculation by a solid germ of the dissolved substance, or of one isomorphous with it, is *necessary* in order to cause the liquid to crystallise; in the labile condition solid germs may be spontaneously generated from the liquid. Take, for example, a test tube filled with a solution of sodium-nitrate containing 48 parts of the salt in 100 parts of solution, which is metastable at ordinary temperatures: if crystals make their appearance in this solution it will only be because the dust of the room contains minute particles of sodium-nitrate which fall into the tube, or because crystals are deposited where drops have evaporated near the surface, and accordingly the first crystals appear at the surface of the liquid, and grow there until they are large enough to fall to the bottom. I find that such a solution, if enclosed in a sealed tube so as to prevent access of germs and evaporation, cannot be made to crystallise above the temperature of 16°, although it is supersaturated at all temperatures below 26°.

Again, let a hot solution of the same strength containing 48 per cent. of the salt be allowed to cool down while being stirred. If dust containing $NaNO_3$ can be excluded, the liquid will not crystallise until the temperature falls to 16°, when the solution passes from the metastable to the labile condition. A cloud of nuclei will then form throughout the liquid, and each will proceed to grow as a separate crystal; the immediate effect is to reduce the liquid to the metastable state so that no more crystals are produced, but each of these continues to grow from the liquid with which it is in contact.

If dust be not excluded, crystals may make their appearance upon the surface of the liquid and will soon sink; but even though they be stirred about actively in the solution the liquid as a whole remains in the metastable state till a temperature somewhat below 16° is reached, when the labile region is entered and a cloud of new crystals makes its appearance.

It follows, therefore, that in a cooling supersaturated solution, from which germs have not been excluded, there are normally two periods of growth: one in which a comparatively small number of isolated crystals are growing regularly, and a subsequent period in which a shower of small crystals is produced. Only if the rate of cooling be sufficiently slow, or the stirring be sufficiently violent, to keep the liquid in the metastable condition will there be no second period, no sudden precipitation of nuclei.

These events take place in all the aqueous solutions which I have examined, and I am surprised that they have not been discovered before. They afford a possible explanation of two common features of igneous rocks, and of slags—namely, the growth of comparatively large and isolated porphyritic crystals, or phenocrysts, and the appearance of the same mineral at two or more different periods. The origin and the arrested growth of phenocrysts have generally been attributed to sudden change of temperature, of pressure, or of hydration, and no other plausible explanation has been given, although, as has been sometimes pointed out, they may occur in bathlolites where there is no independent evidence of such changes. Pirsson has recognised the utter impossibility of the ordinary theory, and has recently suggested that each mineral has its crystallisation interval during which it continues to grow, and that this is terminated by the increasing viscosity of the magma, which checks the supply of further material to the growing phenocrysts and establishes new centres of crystallisation. A similar explanation was adopted by Crosby for the quartz-porphyry of the Blue Hills. He expresses it by saying that owing to the increased viscosity the rate of cooling overtaxes the molecular flow, which cannot keep pace with the crystallisation. It is so difficult to find any satisfactory theory for the growth of phenocrysts that they have even been attributed to the effect of earthquake shocks.

Now in a silicate magma, in all probability, the temperature is sufficiently high to be that of the metastable condition, the rate of cooling sufficiently slow to keep the liquid in that condition for a considerable time, and the viscosity sufficiently great to prevent the growing crystals from sinking at once; we have, therefore, all the conditions favourable for the growth of *porphyritic* crystals; these must have generally originated throughout the liquid as spontaneous nuclei if the magma entered the labile state, or may have been started by inoculation or cooling at the margin if the magma as a whole remained in the metastable state. In the latter case suppose that further somewhat sudden cooling brings the magma to the labile condition, then there will be a sudden and spontaneous second growth of nuclei which will not be able to attain the dimensions of the porphyritic crystals; we have here all the conditions necessary for a *second generation* of one of the constituents of the rock.

It is not necessary, therefore, to suppose that changes of pressure played any very great part in these matters. I believe it will be found that considerations of temperature and solubility are far more important. Similarly, in the case of the salt deposits van 't Hoff came to the conclusion that practically the only effect of changes of pressure is to displace the temperature of formation of the various compounds and not to alter their order or their nature; he estimates that this displacement is comparable with that of the melting-points under the same agency, and in the case of the calcium-magnesium chlorides only amounts to a few thousandths of a degree for one atmosphere of pressure.

Perhaps when we can ascertain the temperature at which silicate

magmas pass from the metastable to the labile condition we may use this knowledge to determine the exact temperature at which certain of their minerals crystallised.

Ordinary petrographical descriptions supply numerous examples of the difference between the metastable and labile conditions to anyone who will read them in the light of the suggestion which I have made; others are to be found in such experiments as those of Vogt or Doelter.

My own hope is that when more experiments have been made upon mixed *supersaturated* solutions it will be found that most, if not all, of the features of rock development are paralleled by the ordinary process of crystallisation, but that motion, supersaturation, and supercooling are most important factors.

The very similarity between the differentiation of the alumo-alkaline and ferro-magnesian minerals on a small scale in the rock, and that of the alumo-alkaline (or salic) and ferro-magnesian (or femic) rocks themselves on a large scale, points to some similarity of origin.

In order to avoid burdening this address with detail I have merely chosen the researches of van 't Hoff, Vogt, Doelter, and Heycock and Neville as illustrations of experimental work conducted on the lines of modern physical chemistry, and have omitted much that might have been mentioned; the valuable researches of Pelouze, Lagorio, Morozewicz, and Loevinson-Lessing, and the melting-point determinations of Joly I have not quoted, because they belong for the most part to an earlier period than that which I am considering, and have been discussed by Teall and other writers.

Many very interesting speculations I have passed over entirely, because my object has been to focus attention upon experimental evidence. I cannot help thinking that these speculations are often based upon chemical actions and equilibria that may be impossible; but we cannot criticise them for lack of evidence, and I return to my original statement that geology is only beginning to enter the experimental stage.

An earnest beginning is, however, being made. The researches on mineral and rock synthesis which I have already quoted are laying a solid foundation; and I see no reason why something of the sort which has been done by van t' Hoff and his collaborators for the aqueous deposits of Stassfurt should not ultimately be worked out for an igneous complex, though it may involve tenfold the labour and tenfold the time. We have already to welcome the establishment by the United States Geological Survey of a laboratory for the express purpose of applying to minerals and rocks the exact methods of modern physics and physical chemistry. The very suggestive research of Day and Allen upon the thermal properties of the felspars is a promise of the sort of work that may be expected from such laboratories.

I fear it will be only too evident to those who have given me their patience during this address that I approach the problems considered in it from the point of view, not of the geologist or the chemist, but

of the crystallographer, to whom the birth and growth of crystals are a study in themselves. Whether we watch with the microscope a tiny crystal growing from a drop of solution, or contemplate with the imagination the stages by which the fiery lavas of past geological periods sank to rest and crystallised, we view the same process; it is the transformation of liquid into crystal. Not necessarily into a solid, for recent research shows that there is no dividing-line between liquid and solid; a plastic solid body may flow; a solid glass is only a supercooled liquid; witness, for example, the experiments of Adams on rocks and of Tamman on supercooled liquids. The real primary distinction is between crystalline and non-crystalline material, and there is even good reason to believe that some crystals are liquid without ceasing to be crystals.

The properties of most rocks, of metals, alloys, ice, and many other substances are due to the fact that they consist of crystals, and the importance of the study of the latter is now, I trust, being brought home alike to chemists, physicists, geologists, and engineers in connection with problems relating to the strength, the movements, the origin, and changes of what are usually called solids.

And so I close, as befits a student and teacher of crystallography, with the hope that renewed attention may be paid to this subject, and that it may attract the interest of many a keen intellect in South Africa. The higher scientific studies are now establishing themselves as an integral part of the educational and intellectual life of the country. This is in no small measure due to the South African Association; and we may hope that the visit of the British Association will be of some help to her younger sister in the task of diffusing a taste and an interest for the pure truths of science and the studies that they both hold dear.

CORRESPONDENCE.

THE TRIMINGHAM BLUFFS.

Sir,—As no stress was laid on the presence of *Belemnitella mucronata* in the Chalk at Trimingham, and we do not consider the erratics of that rock in the Cromer district to have made more than short journeys, we cannot agree with Mr. B. B. Woodward about the importance of the literature of the subject since 1882. One of us was acquainted with the general results of Mr. Brydone's work, but thought minute zonal information had no direct bearing on our objections to Mr. Clement Reid's hypothesis. That of a sea-stack, though less open to stricture, involves some serious difficulties which Mr. B. B. Woodward has apparently overlooked. Surely the majority of these masses at Trimingham cannot be 'stacks.' On the right of the reproduced photograph (Pl. XXII) boulder-clay can be seen underlying the chalk mass (E) at (F), and another one (C) at (D). Again, if (C) merely rests against (A), to form the roof to the tunnel (B) filled with boulder-clay, it must be an erratic, for sea-stacks are not generally mushroom-shaped. The small chalk mass further east, seen in 1900 (p. 399) but now washed away, must, we think, have been a boulder, while if the

original eastern mass, which has met a similar fate, was a stack, the fact (more than once recorded in our notes) that the flint bands in it were fairly horizontal and those in the other sharply curved, was, to say the least of it, singular, for it would require the axis of flexure to have taken a very abnormal course. But if (A) and (C) form parts of one stack the position of the tunnel (B) is hardly less singular, for, instead of looking in the teeth of the waves, it takes a sheltered course more nearly parallel with the coastline. It is therefore highly improbable that any other mass than (A) can be a stack, and if so, it is curiously environed by great boulders. But if it be, what becomes of Mr. Reid's hypothesis? Did the advancing ice-sheet first 'ruck' up the chalk, then retreat to allow the sea to carve out a stack (and make a tunnel if (B) and (C) form one mass), and return to wrap it up in boulder-clay? Or was a pre-Glacial stack mercifully spared by the ice-sheet? In fact, the sea-stack hypothesis involves so many difficulties that Mr. Woodward must pardon us for suggesting the possibility of his having been misled in regard to the chalk in the headland being one mass with that in the platform. In a material like chalk, as we found at the arch, it is difficult to determine continuity or discontinuity, and equally so to trace bands of interrupted flints. But be this as it may, Mr. Woodward has discarded Mr. Clement Reid's hypothesis, and in so doing indirectly justifies our remark that it was out of place in a Survey memoir. To this we adhere, though it may cause "some surprise" to "students of East Anglian geology" (are they a zonal variety?). This is our reason: A Survey memoir is an official publication, which is inevitably invested with authority. It is also published, as the work is done, at the cost of the nation. We therefore hold that it should be a record of facts, not of hypotheses of a more or less tentative or dubious character: these find a proper home in the ordinary scientific periodicals. Thus no one could object to the appearance of Mr. Reid's hypothesis in this Magazine, but in the Cromer Memoir a mention of it with a reference would have sufficed.

T. G. Bonney.
E. Hill.

THE TRIMINGHAM CHALK.

Sir,—May I suggest a small innovation in your usual practice, which would be very grateful to your subscribers, namely, the reprinting of Mr. Brydone's remarkable paper in the Geological Magazine. This paper, to which Mr. B. B. Woodward has called timely notice, has virtually only been privately published, and the fact of its not being quoted by Professor Bonney and Mr. Hill may perhaps be thus explained, although it has been out for *five years*, and is specially quoted and utilized in so accessible a monograph as the portly Survey Memoir on the Cretaceous Rocks of Great Britain, published a year ago (op. cit., pp. 260–264), which also seems to have escaped the notice of the two authors just cited.

[I have procured a copy of Mr. R. M. Brydone's paper, dated August, 1900. It is a pamphlet of 16 pages, and was published separately by Dulau & Co. (price 1*s*.).]

I may add that in regard to Mr. C. Reid's argument and conclusion as to the Trimingham bluffs and their explanation, it is many years since, I think, I conclusively showed the impossibility of his theory, a fact also overlooked by the authors of the much criticized paper in your September number.

30, Collingham Place, Earls Court. Henry H. Howorth.
October 4th, 1905.

OBITUARY.

PROFESSOR BARON FERDINAND VON RICHTHOFEN.

Born May 5, 1833. Died October 6, 1905.

It is with much regret that we record the death of Baron Ferdinand von Richthofen, Professor of Geography in the Berlin University, and eminent alike as a geologist and geographer; who for the last seventeen years taught in that city, and of whom it has been said that there are few among living German geographers who are not proud to call themselves his pupils.

Born at Karlsruhe, Silesia, on 5th May, 1833, he studied first at Breslau, and afterwards at Berlin (1850–6), graduating in 1856. His first geological work was performed in the South Tyrol.

In 1860, with the rank of a Legation secretary, he joined Count Eulenburg's Prussian expedition as geologist, visiting Japan, China, and Siam; he then left the expedition at Siam and continued his travels in Java, Manila, the Philippines, Celebes, and Burma, spending some time in California and Nevada. In 1868 he went to Shanghai and explored for four years a large part of China, returning to Europe in 1872, to work out the results of his travels. The University of Bonn, after electing him to the Chair of Geography in 1875, allowed him to complete the first part of his great work on China before taking up his post in 1879. From Bonn he was transferred to Leipsic in 1883, and to Berlin in 1886, where he continued to lecture until the time of his death. It was by his advice that the German Government selected Kiao-chau as its naval base in the Far East, and have subsequently devoted themselves to the special development and exploration of the province of Shantung.

Baron Richthofen took an active part in the International Geological Congress held in London, September 17th, 1887. In the following year he was elected a Foreign Member of the Geological Society of London, and in 1892 he received the award of the Wollaston Medal from the Council of that Society. On the occasion of its presentation Sir A. Geikie, the President, said of Baron Richthofen's great work on the geology of China, "The massive volumes and splendid atlas which contain his account of China form one of the most important contributions ever made to geological literature" (Geol. Mag., 1892, p. 183). His lectures and writings amply testify to the intimate connection which exists between the sciences of geography and geology, and one is led to wonder how they were ever separated.

Baron Richthofen died on October 6th in his 73rd year. His loss will be felt wherever the sciences of geology and geography are cultivated.

MISCELLANEOUS.

Retirement of Mr. Hugh J. Llewellyn Beadnell, F.G.S.

We regret to announce that Mr. Beadnell, who for nine years has been connected with the Geological Survey of Egypt, has just retired to take up other work in Egypt. He went direct from the Royal College of Science to Egypt when the Geological Survey of that country was established in 1896. In the Winter of 1896–7 he mapped various portions of the Nile Valley between Minia and Esna, and paid a flying visit to the extensive salt deposits in the Eastern Desert between Assiut and the Red Sea. The following Summer he took up the Abu Roash district, which had been described by Walther and Schweinfurth as a Cretaceous complex separated by faults from the surrounding Eocene: Mr. Beadnell's detailed examination showed, however, that the junction throughout was in reality an unconformable one, the faults being entirely within the Cretaceous beds. The following year the examination of the Libyan Desert oases was taken up, Baharia (western portion), Farafra, and Dakhla oases falling to his share. The most important results of this season's work included the discovery of Cenomanian beds in Baharia and extensive phosphatic deposits in Dakhla. The unconformity between Cretaceous and Eocene, found the previous Summer in Abu Roash, was proved to extend to Baharia.

In 1898 he commenced the examination of the Fayûm, though the work was temporarily suspended to complete parts of the Nile Valley further south. In 1901–4 work was continued at intervals in the Fayûm, and systematic excavations for fossil vertebrate remains were undertaken. During part of this time Dr. Andrews, of the British Museum (Natural History), was associated with Mr. Beadnell or encamped within a short distance, and their united labours resulted in the bringing to light nearly forty new genera and species of mammals and reptiles described and determined by Dr. Andrews. A very large collection of the remains of these animals is now exhibited in the Cairo Geological Museum, while a second representative collection has found a home in the British Museum (Natural History).

Among other districts Mr. Beadnell carried out topographical and geological work in Mogara, Wadi Natrun, Kharga Oasis, and the Nile Valley between Esna and Aswan.

On the Egyptian Geological Survey the work is by no means confined to geology, and geologists have to personally carry out a large part of the purely topographical work. He has been three times to the Sudan, spending altogether nearly a year in taking discharges on the White and Blue Niles and the Atbara River for the Egyptian Irrigation Department. He has on two occasions during the Summer months also been in charge of a section of the Revenue Survey.

In 1904 Mr. Beadnell was awarded the "Barlow-Jameson Fund" by the Geological Society of London.

Mr. Beadnell this year resigned his post on the Geological Survey of Egypt, and has taken up the appointment of Manager in the oases for The Corporation of Western Egypt, Limited, a company with Government concessions over a large area, formed to develop the mineral and agricultural resources of the Libyan Desert oases. Work is being commenced in the oasis of Kharga, which will be connected by railway with Farshat in the Nile Valley. The future of the oases depends primarily on the increase of the water-supply, and preparations for extensive boring operations are in progress.

The following is a list of Mr. Beadnell's publications:—

1900. "The Phosphate Deposits of Egypt." Cairo. (Joint.)
1901. "Découvertes Géologiques Récentes dans la Vallée du Nil et le Désert Libyen": Cong. Geol. Int. 1900, Paris.
"Farafra Oasis; its Geology and Topography." Cairo.
"Dakhla Oasis; its Geology and Topography." Cairo.
"The Fayûm Depression, a District in Egypt containing a new Palæogene Vertebrate Fauna": Geol. Mag., December, 1901.
1902. "Note on *Arsinoitherium Zitteli* . . . ." Cairo.
"Some New Mammals from the Upper Eocene of Egypt." Cairo. (Joint.)
"The Cretaceous Region of Abu Roash, near the Pyramids of Giza." Cairo.
1903. "A Land Tortoise from the Upper Eocene of the Fayûm, Egypt." Cairo. (Joint paper with Dr. C. W. Andrews.)
"Neolithic Flint Implements from the Northern Desert of the Fayûm, Egypt": Geol. Mag., February, 1903.
"Baharia Oasis; its Geology and Topography." Cairo. (Joint.)
1905. "The Oases and the Geology of Egypt," in Sir William Willcocks' "Nile in 1904"; London.
"The Phosphate Deposits of Egypt" (2nd ed.). Cairo. (Joint.)
"The Topography and Geology of the Fayûm Province of Egypt." Cairo.[1]
"The Relations of the Eocene and Cretaceous in the Esna-Aswan reach of the Nile Valley." Read at Geological Society, June, 1905.

Royal College of Science, London.—Mr. Samuel Herbert Cox, F.C.S., F.G.S., who has been appointed Professor of Mining at the Royal College of Science, South Kensington, is an Associate of the Royal School of Mines. After being Assistant Geologist and Inspector of Mines in New Zealand he was appointed Instructor in Geology, Mineralogy, and Mines in Sydney Technical College. At the same time he was employed in giving technical lectures at various mining camps in New South Wales, and practised as a mining engineer. Since 1890 he has been entirely engaged in private practice, and has had experience of mining in England, France, Spain, Egypt, the United States, and Canada. He was President of the Institute of Mining and Metallurgy in 1899–1900.—*Morning Post.*

We understand that Professor Chas. G. Cullis, D.Sc., F.G.S., who has acted for some time as Assistant Professor, will for the present continue to fill the Chair of Geology in the Royal College of Science, vacated by Professor J. W. Judd, C.B., retired, and Professor A. Dendy, D.Sc., will deliver the lectures on zoology in place of the late Professor G. B. Howes, F.R.S.

Errata in Mr. A. K. Coomáraswámy's article in the August number:—p. 365, line 13 from bottom, *for* Nanla *read* Naula; line 5 from bottom, *for* wire *read* wise.

[1] See Review in present number of Geol. Mag., pp. 516–519.